Heating and Ventilating

Reg. U. S. Pat. Off.

FORMERLY THE HEATING AND VENTILATING MAGAZINE

C. H. B. HOTCHKISS, Editor
CLIFFORD STROCK, Associate Editor
CLIFF W. PRESDEE, General Manager
GEORGE G. TURNER, Western Manager
JOHN F. HYDE, Eastern Representative

VOL. 28 JUNE 1931 NO. 6

CONTENTS

Editorial 49
A Review of Psychrometric Charts ..... C. O. Mackey 50
The Degree Day—Its Applications and Limitations 54
Smoke Eradication to Save Urban Sunshine ..... F. O. Tonney & C. R. DeYoung 60
Trends in the Cotton Textile Industry ..... C. L. Emerson 64
District Heating Developments in Akron ..... P. A. Hyde 65
Some Temperature Studies in Radiant Heated Rooms ..... T. Napier Adlam 69
Radiant Heating Studied in Britain by Using Scaled Models 73
Shopping of Bids ..... John R. Cooper 74
What Thickness Insulation for Gas Heated Buildings? ..... Paul D. Close 76
Air Conditioning—Part X ..... William Hull Stangle 85

DEPARTMENTS

Abstracts 89
Your Everyday Problems 93
News of the Month 95
New Equipment 103
Monthly Degree Day Data for April, 1931 108
Weather for April, 1931 112
With the Manufacturers 114
Engineers' Specification Index 126
Advertisers Index 136

REFERENCE NUMBERS

September, 1931 Issue—Office Buildings **December, 1931 Issue—Theatres**

Reference numbers already published—School Buildings, September, 1930; Industrial Buildings, December, 1930; Public Buildings and Institutions, April, 1931.

NATIONAL TRADE JOURNALS, INC., 521 FIFTH AVE., NEW YORK, N. Y.

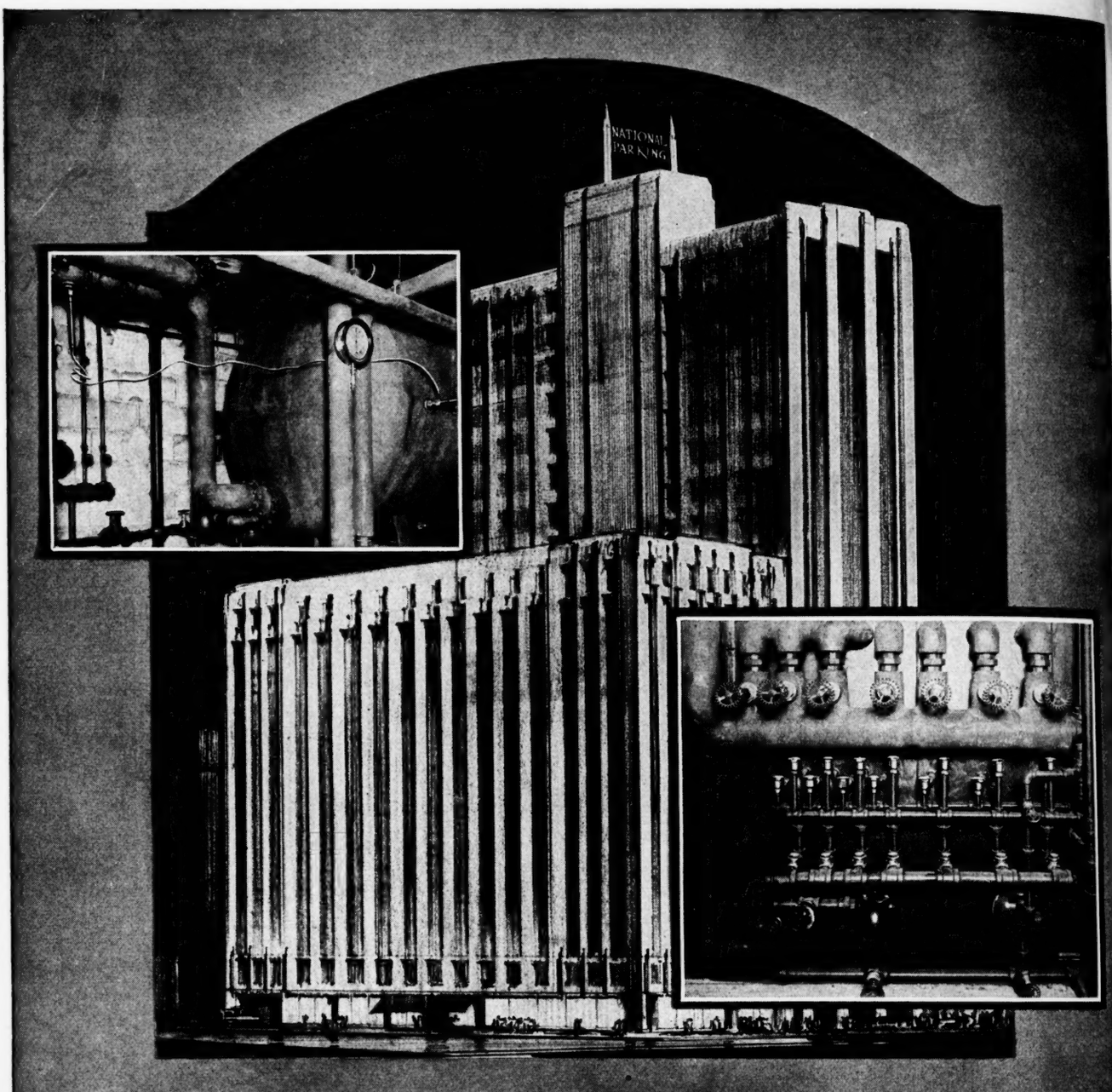
Chicago Office: 75 East Wacker Drive

European Representative, W. G. Hollinworth, Somerleyton Road, Oulton, Lowestoft, England.

Published monthly, $2 per year in United States and Mexico. $2.50 in Canada. $3 in all other countries. Single copies, regular issues, 30 cents. Single copies, reference numbers, $1.

Copyright, 1931, National Trade Journals, Inc.

WHEELER SAMMONS, Chairman of the Board
H. J. BLIGH, President and General Manager
E. J. ROSENCRANS, Secretary and Treasurer



Hotel Harrison and National Parking Garage, Chicago, equipped with Sarco Radiator Traps, Float Traps and Temperature Regulators. A. S. Alschuler, Architect; L. H. Prentice Co., Heating Contractors.

CHICAGO HOTEL INSURES GUESTS' COMFORT WITH SARCO HEATING SYSTEM

By its service a hotel is judged. And of all forms of service furnished, plenty of heat is among the most important. It helps to assure the return of guests.

In selecting the Sarco Heating System, the Hotel Harrison, Chicago, followed the precedent set by hundreds of other fine hotels, apartments, clubs and institutions who put QUALITY before price in choosing equipment.

Sarco Vacuum and Vapor Heating Systems are simple, durable and trouble-proof. Their success is due to the fact that Sarco Radiator Traps, Inlet Valves and other specialties are built, not to sell at a price, but to conform to a high standard of performance. Write for our new Catalog P-40.

SARCO HEATING SYSTEMS
BUILT TO A QUALITY STANDARD

SARCO COMPANY, INC.
183 MADISON AVENUE NEW YORK, N. Y.
Branches in Principal Cities
SARCO CANADA LIMITED, Federal Building, Toronto, Ont.

EDITORIAL

Gas for House Cooling

ANNOUNCEMENT was made some time ago that the American Gas Association will sponsor the installation and operation of gas-powered air conditioning plants in three residences during the coming months. At the recent Memphis meeting the details of the plans were announced. The whole project is naturally intended to promote the use of gas, especially as a means of increasing the summer load. Its initiation is very significant to the whole heating and ventilating and allied fuel and power industries.

In the first place it marks the first attempt of a strong, well organized and well financed trade group to study residential air conditioning on a year-round basis, and to approach the questions of apparatus and operation from a fuel standpoint. Heretofore both apparatus and operating developments have been initiated almost altogether by apparatus manufacturing interests, who to a considerable extent have regarded questions of power and fuel as secondary.

Next, the entrance of the gas interests through their association is almost certain to cause those interested in the competing fuels and in electric power to pay increasing attention to the developments and to likewise study the situation more intensively in order that they also may discover and apply the best possible means of utilizing their products. It is extremely likely, therefore, that we will soon be in the midst of a fact-finding period in year-round residential air conditioning with emphasis on the fuel possibilities and cost of operation.

Many of the improvements in residential heating in recent years can be traced to the fuel interests. Now we may very easily see the story repeating itself in the application of year-round conditioning to these buildings. The field has rich possibilities both for fuel and power and for apparatus. Everyone seems agreed that the application of artificial air cooling to residences will soon be with us in earnest. Evidently the gas interests propose to be in a favorable position fortified with information in their own possession.

The report presented at the recent meeting is also of interest in that it recalls what has been evident for a long time, viz: that it is not necessary to cool air to the dew-point temperature in order to dehumidify it. The dew-point method has been practiced so commonly in air conditioning applications, however, that probably many have overlooked the fact that alternative methods are available. This merely serves to illustrate that when examined from a fuel standpoint air conditioning methods take on peculiar aspects.

Existing practices in the end conditions of relative humidity desirable for residential spaces are also boldly questioned. It seems that those close to the project feel that perhaps it is quite possible to be comfortable in air which is not held at the humidity often advocated. The tests should yield interesting data on this point.

It is too early to form any conclusion as to what the tests may bring forth but certainly every one even remotely interested in the problem of year-round residential conditioning should keep his eyes on the project. It may easily prove to be the initial step in a train of events which will bring about the long-predicted household cooling as a volume proposition.

Regardless of what the outcome of these particular tests may be the gas industry is to be commended for its initiative.

A Technical Adviser for Society Research

ELSEWHERE in this issue we print the announcement of the arrangement made whereby Professor A. C. Willard is to act in an advisory capacity to the committee which directs the research of the A. S. H. V. E. Professor Willard's record of achievement is too well known to need any comment here. His projects have been uniformly notable not only for thoroughness of execution but for the clarity with which objectives have been perceived and the skill with which the results have been presented. Adding the weight of his technical advice to the organization and direction of the work is a tenstrike for the progress of the research activities of the society.

A Review of Psychrometric Charts

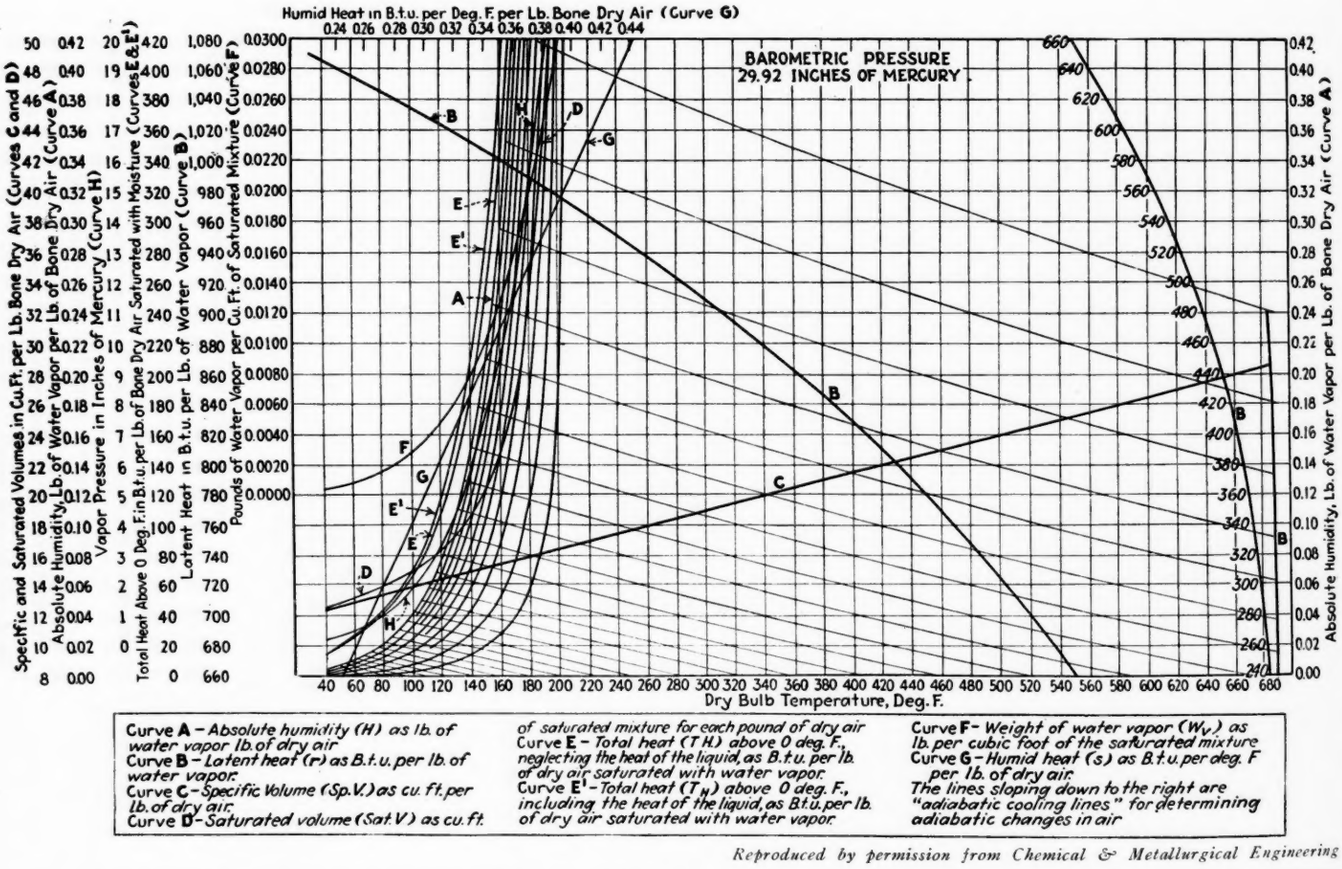
By C. O. MACKEY†

Numerous psychrometric charts have appeared during the past twenty-five years, each of which has its own peculiar advantages and disadvantages. The author analyzes some of the charts and in so doing explains not only how they are used but the principles upon which they were constructed.

IN order to reduce the labor and chance of error in making calculations involving air humidifying and dehumidifying, water cooling, and drying, many psychrometric charts have been devised during the past twenty-five years. It is not the purpose of the writer either to describe or even to mention every such chart. However, those charts which are in most common use at the present time will be analyzed, and illustrative examples, for which each chart is peculiarly adapted, will be given.

As to primary form, most psychrometric charts are network charts. That is, one variable is plotted as ordinate against a second variable as abscissa, and families of curves are drawn *on this coordinate system* for various constant values of a third, and sometimes a fourth, variable. In addition to, but distinct from, this network system, many charts carry various other variables as ordinates plotted against a common abscissa, but these curves will be considered as of secondary importance, because many of these variables could be given as clearly in tabular form, if necessary. Therefore, in studying each chart, the primary coordinate system will be examined first, and the added variables will be mentioned last.

† Assistant Professor of Heat Power Engineering, Cornell University.


Humid Heat in B.t.u. per Deg. F. per Lb. Bone Dry Air (Curve G)
BAROMETRIC PRESSURE
29.92 INCHES OF MERCURY
Specific and Saturated Volumes in Cu. Ft. per Lb. Bone Dry Air (Curves C and D)
Absolute Humidity, Lb. of Water Vapor per Lb. of Bone Dry Air (Curve A)
Vapor Pressure in Inches of Mercury (Curve H)
Total Heat Above 0 Deg. F. in B.t.u. per Lb. of Bone Dry Air Saturated with Moisture (Curves E & E')
Latent Heat in B.t.u. per Lb. of Water Vapor (Curve B)
Pounds of Water Vapor per Cu. Ft. of Saturated Mixture (Curve F)
Absolute Humidity, Lb. of Water Vapor per Lb. of Bone Dry Air (Curve A)
Dry Bulb Temperature, Deg. F.
Curve A – Absolute humidity (H) as lb. of water vapor lb. of dry air
Curve B – Latent heat (r) as B.t.u. per lb. of water vapor.
Curve C – Specific Volume (Sp. V.) as cu. ft. per lb. of dry air.
Curve D – Saturated volume (Sat. V.) as cu. ft. of saturated mixture for each pound of dry air
Curve E – Total heat (T.H.) above 0 deg. F., neglecting the heat of the liquid, as B.t.u. per lb. of dry air saturated with water vapor.
Curve E' – Total heat (T_H) above 0 deg. F., including the heat of the liquid, as B.t.u. per lb. of dry air saturated with water vapor.
Curve F – Weight of water vapor (W_V) as lb. per cubic foot of the saturated mixture
Curve G – Humid heat (s) as B.t.u. per deg. F per lb. of dry air.
The lines sloping down to the right are "adiabatic cooling lines" for determining adiabatic changes in air

Reproduced by permission from Chemical & Metallurgical Engineering

Fig. 1. Psychrometric chart by Lavine and Sutherland for high temperature calculations on air and gases having similar specific heats.

The Grosvenor Chart

In 1908, William M. Grosvenor, in an article on drier design in Vol. I of the "Transactions of the American Institute of Chemical Engineers," presented a valuable humidity or psychrometric chart. This chart, with minor changes, is still used by many chemists and engineers. Walker, Lewis, and McAdams in "Principles of Chemical Engineering" give two such charts, one covering a range of dry bulb temperature from 30° to 230° F., and the other covering a range from 0° to 1000° F. Lavine and Sutherland[1] have prepared a similar chart covering a dry bulb temperature range from 40° to 700° F. The latter chart is reproduced here in Fig. 1. Because this chart may be the least familiar to the heating and ventilating engineer, it will be discussed in some detail.

Explanation of Terms

In connection with Grosvenor's proposed system of units, there are some terms which may not be clear to the reader, and these will first be defined.

1. *Absolute humidity* is the weight of water vapor, in pounds, carried by 1 lb. of dry air.

2. *Percentage humidity*, as used by chemical engineers, might be called *percentage saturation*, and is the ratio of the weight of water vapor carried by 1 lb. of dry air at any given temperature and in any condition, to the weight of water vapor which 1 lb. of dry air could carry if completely saturated at the given dry bulb temperature.

If *relative humidity* be defined as the ratio of the actual partial pressure of the water vapor to the pressure of dry saturated vapor at the dry bulb temperature, percentage humidity and relative humidity are exactly equal, numerically, only for "saturated" and bone dry air. In all other cases, percentage humidity, or percentage saturation, is *less* than the relative humidity of air in any given condition. The relation between relative humidity and percentage humidity for a given air condition is indicated by the following equation:

$$\%\ \text{Relative Humidity} = \%\ \text{Humidity} \times \frac{p_m - p_v}{p_m - p_d} \qquad (1)$$

where p_m = pressure of the mixture of dry air and water vapor,

p_v = pressure of the water vapor in the mixture,

p_d = pressure of dry saturated water vapor at the dry bulb temperature of the mixture.

For example, atmospheric air at a dry bulb temperature of 80° F., with a relative humidity of 60% and a barometric pressure of 29 in. of mercury, has a percentage humidity or percentage saturation of

$$60 \times \frac{29-1.03}{29-1.03} = 59\%$$

Editor's Note: The 1.03 in the above equation is found from saturated steam tables under the column Steam Pressure in Inches of Mercury, opposite 80° temperature.

Observing the primary net work system of this chart, absolute humidity is plotted as ordinate against dry bulb temperature as abscissa. The curved lines of constant percentage humidity labelled with the values 100%, 90%, 80%, etc., are next located on this coordinate system *for a barometric pressure of 29.92 in. of mercury, only,* in accordance with the following thermodynamic relations:

Assuming atmospheric steam obeys ideal gas laws with a gas constant, R = 85.7 ft. lb. per lb. per deg. F., where R for dry air = 53.3, the ratio of the weight of water vapor to the weight of dry air, or the absolute humidity, is given by the ratio of their respective densities. So for "saturated" air,

$$\text{Absolute humidity} = AH = \frac{53.3}{85.7} \times \frac{p_d}{p_a}$$

$$= 0.622 \frac{p_d}{p_a} = 0.622 \frac{p_d}{29.92 - p_d} \qquad (2)$$

where p_d=the pressure of dry saturated steam at the dry bulb temperature in in. of mercury.

Since p_d may be found for different dry bulb temperatures and substituted in this equation, AH for 100% humidity may be calculated and plotted against the dry bulb temperature. The curves for any other percentage humidity are obtained by taking the corresponding percentage of the 100% humidity value at the desired temperature.

For example, if t = 80°F., $AH_{100} = 0.622 \frac{1.03}{29.92 - 1.03}$ =0.0222; AH_{50}=0.5 × 0.0222=0.0111 lb. steam per lb. dry air.

Explanation of the Adiabatic Saturation Process

The fourth variable of the net work chart is disguised. The lines which slope downward to the right are called adiabatic cooling lines. In explaining the location of these lines it is pertinent to discuss the "adiabatic saturation" process.

Suppose there is a long tunnel with some thermal insulating material for walls, along the bottom of which is a shallow pan or other container of water at a temperature, t_2, which extends the entire length of the tunnel. Assume that one pound of dry air with accompanying water vapor, AH pounds (the absolute humidity), enters at one end and flows with a velocity which is practically constant and high enough to insure vapor diffusion over the water surface and out. The temperature of the air will fall in passing through the tunnel, and if enough water surface be supplied, the water and air will ultimately come to an equilibrium

[1] "Revised Psychrometric Chart Assists High Temperature Design," Chemical & Metallurgical Engineering, Vol. 35, No. 4, April, 1928, page 226; also "Calculating Lignite Drier with Psychrometic Chart," Chemical & Metallurgical Engineering Vol. 36, No. 7, July, 1929, page 425.

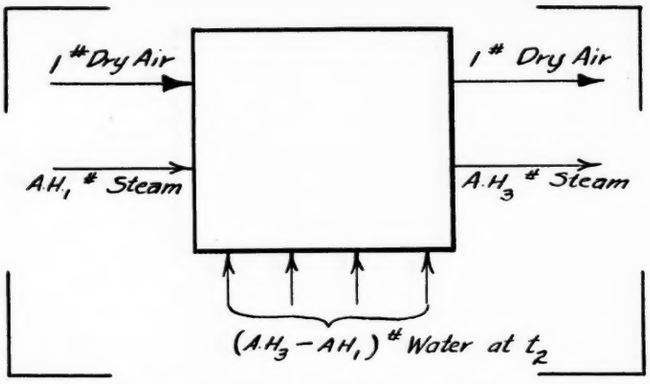


Fig. 2. Diagram showing application of general energy equation.

temperature, t_3, and each pound of dry air will carry AH_3 pounds of water vapor. This process of saturation is adiabatic in the sense that the only heat transfers which are assumed to be occurring are those between the air and water, i.e., there is no external supply to or abstraction of heat from the air and water in the tunnel. By actual experiment, W. H. Carrier and D. C. Lindsay[2] have shown that the equilibrium temperature attained is substantially the initial wet bulb temperature of the air. Furthermore, W. K. Lewis has demonstrated[3] mathematically that the wet bulb temperature of the air remains substantially constant during the adiabatic saturation process for the small amounts of vapor carried by the air in such common processes.

Adiabatic Cooling Lines Are Constant Wet Bulb Lines

The mask is now off the so-called adiabatic cooling lines. They are nothing but lines of constant wet bulb temperature and might just as well be labelled as such. They are lines which represent, graphically, the adiabatic saturation process on the primary coordinate system of this chart. As to the numerical value of the constant wet bulb temperature on any given cooling line, it is that dry bulb temperature at which the cooling line intersects the 100% saturation curve.

The numerical calculations back of the location of these cooling curves on the coordinate system of absolute humidity vs. dry bulb temperature has been given many times, but it is desired to present the problem here in a manner that differs from the common explanations, and which is favored by many teachers of thermodynamics.

The general energy equation can be applied to this adiabatic saturation process to give a simple solution. For those not familiar with this handy tool of thermodynamics, it suffices to say that we shall equate the energy of the fluids entering the tunnel to the energy of the fluids leaving this tunnel with the following assumptions:

(a) Changes in potential and kinetic energy of the fluids are negligible during the process,

(b) There is no external transfer of heat to or from the fluid.

With reference to Fig. 2, the heat content of the entering mixture of dry air and steam per pound of dry air plus the heat content of the evaporated water must equal the heat content of the leaving dry air and steam per pound of dry air.

In equation form,

$$h_{m1} + (AH_3 - AH_1)h_2 = h_{m3}$$

Using 0.241 as the specific heat at constant pressure of dry air, and an empirical equation for the heat content of low pressure saturated or superheated steam derived from J. H. Keenan's steam tables, viz.:

$$h_s = 1059.2 + 0.45\ t_s,$$

$$h_{m3} - h_{m1} = 0.241\ (t_3 - t_1) + AH_3(1059.2 + 0.45\ t_3) - AH_1(1059.2 + 0.45\ t_1)$$

But $t_1 = t_3 + (t_1 - t_3)$, and

$$h_{m3} - h_{m1} = (AH_3 - AH_1)h_2 = 0.241(t_3 - t_1) + AH_3(1059.2 + 0.45t_3) - AH_1[1059.2 + 0.45t_3 + 0.45\ (t_1 - t_3)]$$

$$(AH_3 - AH_1)h_2 = (AH_3 - AH_1)(1059.2 + 0.45t_3) - 0.45AH_1\ (t_1 - t_3) + 0.241(t_3 - t_1)$$

$$(AH_3 - AH_1)h_2 = (AH_3 - AH_1)(1059.2 + 0.45t_3) - (t_1 - t_3)\ (0.45AH_1 + 0.241)$$

$$(AH_3 - AH_1)(1059.2 + 0.45t_3 - h_2) = (t_1 - t_3)\ (0.45AH_1 + 0.241)$$

If humid heat, S, be defined as the quantity of heat required to raise one pound of dry air with whatever water vapor it carries 1° F., during a constant pressure process,

$S_1 = 0.241 + 0.45AH_1$, and

$$(AH_3 - AH_1)(1059.2 + 0.45t_3 - h_2) = S_1\ (t_1 - t_3)$$

$$t_1 = t_3 + \frac{(AH_3 - AH_1)(1059.2 + 0.45t_3 - h_2)}{S_1} \qquad (3)$$

This equation gives the relation between the several variables for adiabatic evaporation of water into air when the water is supplied at the temperature t_2. In case the water is supplied at the wet bulb temperature of the air (t'), and the air is completely saturated during the process, $t_3 = t_2 = t'$, and the difference between the heat contents of the dry saturated steam and of the liquid at t' is the latent heat of vaporation at this temperature, viz., r'.

$$t_1 = t' + \frac{(AH' - AH_1)\ r'}{S_1} \qquad (4)$$

where $S_1 = 0.241 + 0.45\ AH_1$ (5)

Equation 4 may be used to plot any adiabatic cooling

[2] "The Temperatures of Evaporation of Water into Air." Trans. A.S.M.E., Vol. 46, 1924, page 739.

[3] "The Evaporation of a Liquid into a Gas," Trans. A.S.M.E., 1922, page 325.

line or constant wet bulb temperature line on the coordinate system of AH vs. t.

How to Use the Sutherland-Lavine Chart

For example, with reference to Fig. 1, consider the cooling line which intersects the 100% saturation curve at t = 120° F. This cooling line may be considered as a line of constant wet bulb temperature, t', of 120. At saturation at this temperature, AH' = 0.081. To plot an intermediate point on the line of constant wet bulb temperature, solve equation 4 for t_1 when AH_1 = say 0.04.

$$\text{Then } t_1 = 120 + \frac{0.241 + 0.45 \times 0.04}{0.041 \times 1025.6}$$

$$= 120 + 162 = 282° \text{ F.}$$

It will be noted that on the chart for t = 282 and AH = 0.04, t' = 120.

Summary

In summary then, in Fig. 1 we find lines of constant percentage saturation and of constant wet bulb temperature (in the guise of adiabatic cooling lines) plotted on a coordinate system of absolute humidity vs. dry bulb temperature. Of the auxiliary variables on the chart, all are plotted as ordinate vs. temperature as abscissa except humid heat, S, which is plotted as abscissa vs. absolute humidity as ordinate. The only two of these variables which are used in relation to each other are the specific volume of dry air and the volume of a saturated mixture per pound of dry air. It is possible to interpolate between these curves on the basis of percentage saturation to determine the volume of any mixture of dry air and water vapor per pound of dry air at a given temperature and a pressure of 29.92 in. of mercury. *For example,* interpolating between curve C and Curve D at t = 110° F., a mixture having 60% humidity (either percentage saturation or relative humidity, since the interpolation is rough), would have a specific volume of about 15 cu. ft. per lb. of dry air present in the mixture.

Grosvenor originally designed his psychrometric chart for use in drier design, and charts like the one of Lavine and Sutherland, shown in Fig. 1, are extremely useful in making calculations in problems on drying. To illustrate the use of the chart, a typical numerical example will next be solved.

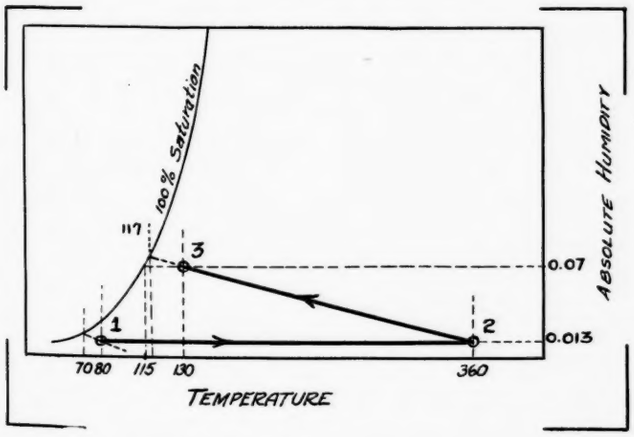


Fig. 3. Skeleton chart showing use of chart shown in Fig. 1.

Use of Chart for Drier Problems

Suppose that atmospheric air at a dry bulb temperature of 80° with a wet bulb temperature of 70° and normal barometric pressure, be heated to a dry bulb temperature of 360° and passed through a direct contact drier, which the air leaves with a dry bulb temperature of 130°. Required, the location of the state point of the exit air on the primary coordinate system of the chart, and the weight of water vapor picked up per pound of dry air circulated. To make the use of the chart clear, a skeleton chart is here presented in Fig. 3, with the different points labelled.

The initial state of the air, 1, is located at a dry bulb temperature of 80° and on a cooling line (constant wet bulb line) which intersects the 100% saturation curve at a temperature of 70°. At this state point the absolute humidity of the air is read to be about 0.013 lb. per lb. of dry air. The state of the air entering the drier, 2 is next located at this absolute humidity and at a dry bulb temperature of 360°. Assuming a drying process with no external heat transfer the adiabatic "cooling" line which passes through state 2 is followed up to a dry bulb temperature of 130°, thereby locating the state of the air leaving the drier, i.e., 3. At state 3, the absolute humidity is read to be 0.07 lb. per lb. of dry air. By following the adiabatic line to the 100% saturation curve the constant wet bulb temperature for the drying process is found to be 117°. If the dew point of the exit air is required, it is found by the intersection of the 0.07 absolute humidity line with the 100% saturation curve, and is 115°. Each pound of dry air has picked up 0.07 — 0.013 = 0.057 lb. of water vapor in the drier.

Of the secondary lines on the chart, the only two of any special interest are curves C and D. Noting the percentage saturation at state point 3 to be about 62, and interpolating between curves C and D at 130° on this basis, the humid volume of the exit air is found to be 16.3 cu. ft. per lb. of dry air.

Straight Lines, Range and Units Make Chart Valuable for Drier Work

By changing the ordinate scaling from uniform to logarithmic, the sharp rising of the percentage saturation curve at high dry bulb temperature could be reduced, and lines of lower constant percent saturation could be added. This would be of doubtful value, however, because the adiabatic cooling lines would be curved down, and for drying calculations it is advantageous to follow the nearly straight adiabatic line. It is the very fact that these lines are nearly straight together with the temperature range and the use of Grosvenor's scheme of units, where all variables are put on the common base of 1 lb. of dry air, that makes this chart so satisfactory for use in calculations on drying.

(To Be Continued)

The Degree Day — Its Applications and Limitations

Considerable evidence has come into existence since the degree day was originated showing that this unit is limited in its applications. The article describes why it is essentially an estimating unit, and analyzes the factors, among which are wind, rain and sun, which cause seasonal variation in its accuracy. Some evidence is included tending to show that the unit is not appropriate for short-period estimates.

USE of the degree day as the basis of a method for estimating fuel consumption is now widespread. The unit, following its announcement, was rather rapidly adopted. At present degree day units are computed, tabulated and available as long-period seasonal averages, and current records for many localities are also kept. Both opinion and practice seem to be agreed on its general usefulness as an estimating unit.

The fundamental conception of the unit is that it is an expression of the severity of the heating season so far as outside temperature is concerned. The conception is probably a true one.

Actual application of the unit to fuel consumption estimating, however, goes beyond this conception and assumes that the degree day is a measure of either the fuel used or the energy required. Thus, if one heating season in a given locality is twice as severe as another in outside temperature depression a degree day method of estimating would predict that the fuel consumption in the one case should be twice that in the other.

Bearing in mind that the degree day takes into account changes in outside temperature from some set base temperature and uses the mean variation in a twenty-four hour period, it is apparent that it varies with the fuel consumption only in case it is granted that (a) the base temperature is maintained during the full 24-hour interval, (b) the outside temperature is a true mean for the period, and (c) fuel is used strictly in accordance with outside temperature changes.

Assumptions for 24-Hour Period Extended to Season

This would apply to the particular 24-hour period and to extend the idea to seasonal consumptions it is necessary to assume that these conditions obtain over the whole period considered.

As short-hour heating with lowered temperatures during a considerable part of each day is so widely practiced, the maintained temperature taken as the base for calculating is evidently not to be taken at some arbitrary point such as 70° unless the temperature is actually maintained. Usually the base temperature would be a weighted mean of the temperatures existing at the several hours. This figure is difficult to determine with any degree of accuracy unless automatic control apparatus is used. Even with such apparatus it is problematical as to just what accuracy will result when a long period is considered. Moreover, since the temperature is assumed to exist over the whole building, a temperature reading at one point may not in any way represent the temperature existing in the whole building.

The outside temperature as a daily mean has been shown to be reasonably approximated by the method used at the government weather stations. The long period over which this information has been collected and studied makes the reported daily mean a reliable statement for use.

Fuel Consumption Depends on More Factors Than One

Fuel does not in general vary strictly in accordance with outside temperature changes in any one day and this is the essential weakness of the degree day as a measuring unit. Instead the fuel used is certainly dependent on the method of operating and controlling the plant, on the construction and use of the building, on the efficiency with which the fuel is utilized, and on wind, rain, and sunshine conditions. The actual fuel consumed is thus dependent on many factors of which the outside air temperature is only one.

In considering the faithfulness with which fuel consumption follows temperature changes, let us first consider the effect of the method of operating and controlling the plant. Evidently the methods must be adjusted to the plant. Thus if the plant is coal-fired the method is almost certain to be sharply different from that used with a gas or oil-fired plant.

In most cases it is necessary to use some fuel to maintain the heating plant in a ready-to-serve condition during long periods of the season even when no heat is needed to keep up the temperature of the heated space. The fuel used for this purpose will not be the same for

every class of fuel either as a total or as a percentage of the total used. In the main, gas-fired equipment requires only the maintenance of a very small pilot light which consumes but little fuel. Oil requires little or even no fuel to be burned continuously for this standby service. City steam can be shut off completely and meter readings on which consumptions are usually based might show no standby fuel although the central plant would be using fuel. An isolated coal-fired plant would, however, use considerable amounts of fuel for standby since ordinarily only one heating unit is available and the fire bed must be maintained against the early morning demand.

Of all the operating factors which affect fuel consumption the item of standby fuel is one of the most significant, for it actually increases in importance as the outside temperature increases or as the degree day figures decrease. Fig. 1 shows a curve illustrating how this item may be expected to vary during the heating season. Curve A shows that during the mild weather in the late spring and early fall the standby fuel is a large proportion of the total daily fuel used, while during the cold weather with the plant operating near capacity the standby fuel is negligible or even nothing in case of 24-hour heating. Curve B shows how the degree day load varies during the period.

So far as known, no published information has appeared showing just how to evaluate curve A numerically for any kind of fuel, nor is any information available as to how large a part of the total fuel the standby is. It can be safely predicted, however, that with the methods now in use standby coal is a larger proportion of the season's total than is standby oil or gas.

The construction and use of the building affects the fuel consumption in that loose construction increases infiltration while light or high conductivity walls increase transmission. The construction also has a very important bearing on the effects of sun and rain, as will be discussed later.

Construction of Building to Be Considered in Comparisons

For a given building the construction can be taken into account in the design of the plant and is therefore to some extent eliminated if the consumption is based on the assumption that the installation is properly proportioned. This is sometimes done when consumptions are expressed as units of fuel per unit of heating surface combined with the degree day. When the consumptions of different buildings are compared by methods based on such units, however, the fact that the construction does affect the consumption cannot be avoided and must be compensated for. If not done as above, a corresponding correction must be made in the assumed efficiency of the plant.

On the whole there is no strictly seasonal variation in the fuel consumption due to the construction of the building except the variations due to the effects of sun, wind and rain on the structure and the variations in outside temperature. Instead the construction affects the consumption of fuel throughout the whole season to a considerable extent.

The efficiency of the heating plant as a whole and also the efficiency of the conversion of fuel into heat in the combustion apparatus affect the fuel consumption.

Definition of Efficiency Enters Into Problem

The efficiency of the whole plant lacks definiteness. It is easily defined as the ratio of the heat used to the heating value of the fuel. However, there is difficulty in determining what the heat used actually amounts to. Not only is this true numerically but there is little agreement as to just what should be thought of as the heat used. Some contend that it should be the heat needed as determined by calculations of the heat lost from the heated spaces. Others feel that the correct conception is to take the heat used as being all the heat generated in the entire building—or supplied to it—less any heat lost through the stack or through discharging heated air or hot condensate. Moreover, there is difference of opinion as to whether or not inefficiencies actually built into the heating system should be considered or not, or, if considered, what weight should be attached to them.

Regardless of the merits or demerits of the method to be used in arriving at the efficiency of the whole plant the combustion efficiency or efficiency at the burning apparatus affects the fuel consumption. No matter how the effectiveness of utilization of the generated heat may be considered it is evident that the overall efficiency can be no better than that of the furnace or boiler. Changes and variations in this will certainly make themselves felt in the fuel used.

Let us then consider only this item to note if there is any marked variation in it which is related to changes

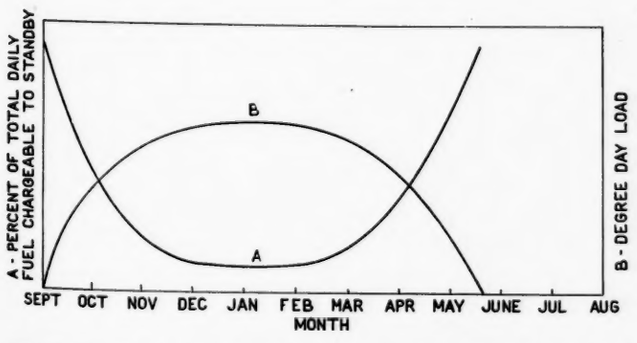

A - PERCENT OF TOTAL DAILY FUEL CHARGEABLE TO STANDBY
B - DEGREE DAY LOAD
B
A
SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE JUL AUG
MONTH

Fig. 1. Variation of standby fuel (A) and degree day load (B) through the heating season.

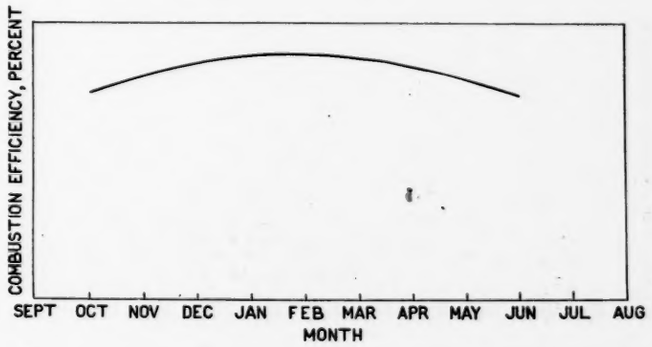


Fig. 2. Variation of efficiency with severity of weather.

in outside temperature. Since most furnaces and heating surfaces are proportioned to operate at their best efficiencies at full load, there is a falling off at other loads. The amount of the decrease will vary greatly with the fuel used, with the particular design of heater used, and with the way the units are assembled and operated.

Number of Units May Affect Efficiency

In the case of isolated coal-burning plants having but one boiler or furnace the falling off in efficiency between full load and no load is a considerable figure. In the case of multiple-boiler or furnace installations the falling off may be controlled to some extent by operating only as many units as needed and attempting to keep each operating at its most efficient point. Too, standby fuel can be lessened by this method.

In the case of oil and gas units much the same is true. There will be a falling off in efficiency at times of light loads. The standby losses and the lowering of efficiency may also be decreased by the use of multiple units and possibly by the use of multiple burners.

Fig. 2 shows graphically the way the efficiency might be expected to vary, i.e., with a curve convex upwards. Just how sharp the curvature would be will depend on the particular equipment. Undoubtedly with the apparatus and methods of burning in common use neither the same maximum points nor the same curvatures would be found for coal as for oil or gas. While there is some numerical evidence in existence to prove this point, it is widely scattered and is seldom if ever actually applied in this way.

The curve brings out well the fact that in spite of the fuel used there is a considerable tendency toward a lower efficiency in the early fall and late spring than during the coldest weather. This is quite a different consideration from the changes in standby losses at these same seasons although related to them.

Radiant Heat from Sun Affects Fuel Consumption

Heat absorbed on the surfaces of buildings from the radiant heat of the sun is certainly a factor affecting the fuel consumption. Unfortunately, but little information is actually in existence in such form that it can be applied directly to fuel estimating. The amount of heat so absorbed can be definitely predicted to depend on the character of the surface, on the hours of sunshine and on the angle of incidence of the sun's rays. It is extremely unlikely that the above listed factors are all those involved. Moreover, just what happens to the heat so absorbed is problematical. Some is conducted away by the air and some may be conducted into the building walls under certain conditions. While numerical information is lacking, the general tendency is clear. The heat absorbed on the wall surfaces certainly tends to reduce the flow of heat from the building and should therefore reasonably be expected to make itself felt in the fuel required. A second factor is that the amount of heat so absorbed is not directly related to the outside air temperature but is indirectly related to it. It is therefore another factor somewhat independent of outside temperature.

The table which follows shows the clear and partly cloudy days of the heating months for 1929-30 as taken from weather bureau reports for five cities:

		New York	*Boston*	*Pittsburgh*	*Chicago*	*St. Louis*
Oct. 1929	Clear	9	10	7	12	14
	Partly Cloudy	12	10	12	5	4
Nov. 1929	Clear	3	9	5	11	9
	Partly Cloudy	11	8	8	4	9
Dec. 1929	Clear	6	7	1	4	10
	Partly Cloudy	8	11	6	3	6
Jan. 1930	Clear	3	7	4	8	13
	Partly Cloudy	6	7	6	7	3
Feb. 1930	Clear	5	14	2	3	9
	Partly Cloudy	11	8	9	10	9
Mar. 1930	Clear	9	12	8	10	15
	Partly Cloudy	12	12	8	8	9
Apr. 1930	Clear	6	11	9	11	12
	Partly Cloudy	12	13	6	8	14

While the table is for the one year only it may probably be taken as roughly indicative of the way the periods of sunshine vary from month to month. There is no clean-cut proof that the combined clear and partly cloudy days are an index of the sun effect. In fact, during the mild months when these days increase in number, the sun's angle is decreased and the heat received per unit area should increase. In other words the sun's effect should be even more marked at these periods than the figures given in the table would indicate.

Some little experimental information is available on this point. As a result of observations made on the research residence at the University of Illinois[1] it appeared that the heat consumption could be expected to be reduced 10% daily by a full day of bright sunshine. This result is the mean of some twenty tests apparently. Since only days of practically complete sunshine were analyzed the effect of partly cloudy days was not shown. This particular study showed little variation in the saving to be expected regardless of whether the day was cold or warm.

The studies made at the experimental house of the British Building Research Board[2] also yield some experimental information.

This house was heated with electric convector type heaters and was of somewhat different construction than the other. Observations were made for days of three hours or more of sunshine. The result was essentially similar to those reported in the Illinois studies. The actual requirements on these days were less than those computed on the basis of outside temperature alone, and did not bring out any seasonal trend in the variation.

Rain as an influence on fuel consumption has been investigated but slightly. However, the fact that the moisture content of the materials in a building greatly affects their conductivity is well established. Moisture seems to increase the heat flow and therefore its effect would be expected to increase the fuel consumption. Studies by the British Building Research Board also

[1] "Investigation of Warm-Air Furnaces and Heating Systems," Part IV; University of Illinois Bulletin, No. 189; page 82.

[2] HEATING AND VENTILATING, May, 1931, page 85; or "Report of the Building Research Board" (Great Britain,) 1929, pages 81-84.

confirm this conclusion. In the same report already referred to the effect was found to be less marked than the effect of the sun.

Rain is so variable in its occurrence that the seasonal trend is a difficult factor so far as the heating season goes. In general, though, there is more rain in the fall and spring months than during the coldest months. Whatever effects it has are largely independent of the air temperature and may be expected to make themselves felt most sharply at the extreme ends of the season.

Data on Effect of Wind Not Entirely in Agreement

The effect of wind on the fuel consumption is rather well known and has been made the subject of several investigations. The effect varies with the velocity and also with the outside temperature. Thus, a high wind at a time when the outside temperature is 0° has a greater effect on the fuel consumption than one of the same velocity on a warmer day. This has been borne out both by common experience and by a number of studies. While the numerical data cannot be said to be fully satisfactory, more useable information is at hand on this point than on any of the others so far mentioned. Naturally, the data are not entirely in agreement.

Because of the peculiar effect of the wind, the fuel consumption during the mild weather months is relatively little affected by the wind. The worst effects occur during the cold months for in many localities the highest velocities also occur during the colder months.

To summarize, considering the fuel consumption over the heating season the following factors tend to *increase* the consumption beyond what would be expected by changes in outside temperature only, provided a fixed daily mean inside temperature is maintained:

(a) standby fuel,
(b) decreases in combustion efficiency,
(c) rain and wind.

At the same time the sun's heat absorbed is tending to *decrease* the fuel consumption.

Factors May Tend to Oppose Each Other

Whether or not the actual fuel consumption really varies with the outside temperature will depend upon the way these opposing tendencies interact.

It has been pointed out that at the time the factors (a) and (b) may be expected to exert their most telling effects to increase the consumption, the sun is most effective in checking this tendency. If the sun's heat exerts a greater effect than these other factors in mild weather the actual fuel consumption may be less than would be predicted by temperature changes only. If it just counterbalances their combined effects the consumption should follow these temperature changes. If it fails to add enough heat to check their tendency then the fuel consumption may be expected to be greater than would be predicted by temperature changes only.

During the cold periods the factors (a) and (b) reach their stage of least importance and the wind factor (c) becomes most effective in tending to increase the consumption while the sun's heat reaches its minimum effect in tending to decrease the consumption. If the wind's effect is greater than the sun's effect the consumption may be expected to be greater than would be predicted, and vice-versa.

There is considerable evidence in existence tending to prove that at the extreme ends of the heating season the sun's effect actually does become a controlling factor and that during these periods the consumption really becomes less than the predicted. So also during the peak of the season the wind becomes a controlling factor and consumptions are greater than would be predicted by temperature changes.

In the normal season and in most localities, therefore, the total seasonal consumption stands a good chance of following the outside temperature changes fairly well since the deficiencies at the ends of the season tend to counteract the surpluses of fuel used during the extremely cold periods. This fact is substantiated by the long experience, perhaps not fully stated but implied, that fuel consumptions certainly do vary with outside temperatures. In other words, while outside temperature is not the only factor involved, it certainly is a very major factor. The successful use of the degree day unit in predicting seasonal consumptions also lends confirmation to the basic soundness of this conclusion.

Abnormal Sun or Wind Will Throw Calculations Off

The discussion must also include a statement of what relative reliability may be expected from the degree day method during seasons which are abnormal. Applying the same reasoning as above to a mild season with a surplus of sunshine and a minimum of wind and rain, it would be expected reasonably that the fuel actually used would be less than would be estimated by a purely temperature method. This conclusion is also borne out by what data are at hand. The opposite would be expected during an abnormally windy season with little sunshine, and again experience in use seems to bear it out.

One case which is abnormal in a sense is the climate where the outside temperature for long periods during the winter stays close to the point where artificial heat is either required or not required. That is, while the total heat requirement may be considerable, the daily load is not great. This situation occurs on the west coast. Moreover, sunshine and rain are considerable factors in these localities. As a result the degree day unit seems to bear little relation to fuel consumption in these places.

Degree day units have also been widely used for estimating consumptions over relatively short periods such as monthly, or even shorter periods. Since the successful use over a long period, like a full heating season, depends so much on a balance being struck between excesses and deficiencies, it is evident that the shorter the period the less is the likelihood of a balance being set up.

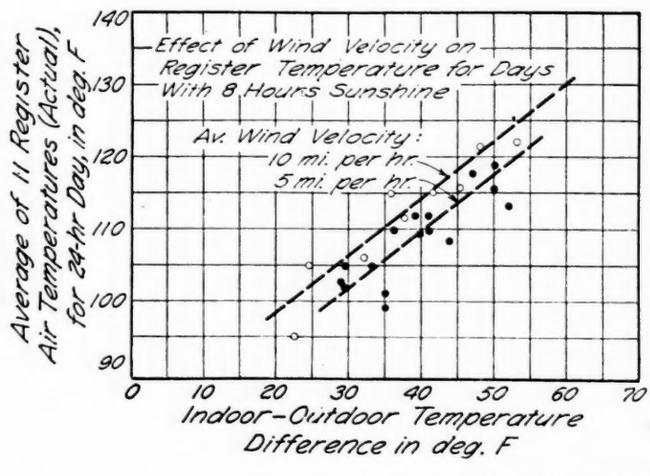
This leads to the question of just how short a period can be used and still be expected to yield reasonably accurate results. Some little information is available on which to base an estimate.

It has been found that for buildings constructed with heavy brick walls (8 to 12 in.) the actual effects of sunshine persist for some hours and that the flow of heat through them is very sharply different than would be expected if equilibrium of flow were established. Laboratory experimenters have repeatedly shown that actual equilibrium of flow can be obtained only after deliberately keeping all conditions carefully constant for considerable periods. Where not only outside temperature but sunshine, rain and wind are continually varying it is practically impossible to analyze their combined effect on heat flow over a short interval. Certainly it would seem well within reasonable limits to conclude that a single twenty-four hour period is entirely too short a one on which to place any dependence in estimating fuel consumption by a degree day method or by any variation or derivative of such a method. A seven day, or weekly, period might be justified but certainly it too is too short not to involve considerable risk.

Degree Day Not Accurate for Short Interval Estimating

On the whole it is doubtful if the use of the degree day as an estimating unit should ever be applied to periods shorter than the month. Certainly its use for shorter periods cannot be expected to yield results of any degree of accuracy. Where rough results only for short periods are desired, its use is probably satisfactory and as accurate as any method yet devised. Corrections and modifications based on the meager data available are sometimes applied to the degree day when it is used for short-period estimating and probably increase the accuracy of the estimation but to what extent is still problematical.

Some light may be shed on the short-period use of the unit by examining the results of the several investigations which to date have yielded numerical data under conditions controlled closely enough to be of direct value.



Univ. of Ill. Bull. 189.

Fig. 3. Curve showing register air temperatures at various outside temperatures on days with eight hours sunshine.

Interesting Data Revealed by Tests

The experimental house of the British Building Research Board was operated under a carefully controlled electric heating method during 1928-29. The records of the days showing rain and wind and sunshine were carefully kept and correlated. These days were grouped into groups having as nearly like characteristics as possible. Examination of the charts resulting from plotting the averages of each group shows strikingly that the individual points fall off the curves of the mean computed line in spite of their selection for like characteristics.

Fig. 3 is plotted from data shown in a bulletin of the University of Illinois[3]. The circles are the points for individual 24-hour periods. The scattering of the points both above and below the mean line shows how sharply the individual values vary in spite of the fact that these particular tests were selected because the observed conditions of sunshine and wind were practically similar. Obviously, if any one point were selected as a basis on which to arrive at a conclusion, it might be very sharply different from either the mean or from any other individual test. This demonstrates rather conclusively the fallacy of attempting to apply degree day methods to short periods, even if sunshine and wind are taken into account.

Little Experimental Data to Justify Use of Degree Day for Short Hour Estimating

A number of studies have been attempted and their results are available in which the periods have been from 48 hours to one month. Attempts to carefully analyze the results have indicated that in most cases so many variables have entered the tests that they are not comparable with each other nor can consistent results be obtained. For instance, flow meters have been used to measure quantities in some tests and condensation meters have been used in others. In still other reports the results are really in terms of steam or energy used within the building while others are in terms of fuel, and the only correction made is an assumed efficiency factor. More careful operation of the apparatus in some cases than in others can doubtlessly be credited with some of the discrepancies. In others, while mean temperatures, mean wind velocities and mean rainfall are nearly the same, the actual detailed quantities are greatly different. In practically every case the published results when examined critically show that as soon as the results are analyzed in short intervals like 48-hour periods, inconsistencies result over what would be expected by temperature differences. It is therefore safe to conclude that at present there is little justification, either analytical or experimental, to justify the use of degree day units for short interval estimating.

Another point in connection with the use of the degree day for estimating is the relative correctness of the estimates for the several fuels available. This has already been touched upon to some extent. In general, those fuels used in connection with automatic control and with little or no standby losses should lend them-

[3] Bulletin No. 189, page 80.

selves most readily to the use of the degree day units. This is because the fuel actually used should follow the requirements closely and with the least deviation. Thus, electricity, gas, oil and city steam under full control can scarcely be compared for estimating accuracy with a small coal-fired plant operating with only indifferent control and attention. Such a coal-fired plant can scarcely be expected to follow the demands closely and the fact that but poor success has been realized in attempting to apply the degree day to estimating coal requirements for residences is not surprising in view of the wide differences in individual installations and in their operation. The unit as actually applied involves the use of an assumed efficiency and probably some of the failures to get expected results in individual cases with coal-fired plants can be ascribed to the practice of using a sort of blanket figure for the efficiency of all coal-fired installations. Instead, it is reasonable to expect that such installations vary all the way from those having very high seasonal efficiencies to those giving very low ones. On the other hand degree day units have been very satisfactory on the whole in estimating gas fuel requirements. This in turn may be largely due to the similarity of gas installations in that practically all are under automatic control and that gas follows the requirements of demand closely with relatively little standby loss resulting in relatively constant efficiencies for different installations.

The successful use of the degree day with gaseous fuel brings up another point which is confusing in the use of the unit. That is the fact that there are now degree day units computed to more than one temperature base. For instance, bases of 65°, 55° and 45° are now used.

Base of 65° Works Well With Gas as Fuel

The 65° basis for computation originated when the unit first came into prominence and was used in estimating gas fuel for residences. There is some confusion as to how the 65° base is arrived at. It can be computed as the mean temperature during a 24-hour period when 70° is maintained for 18 hours and 50° for 6 hours. It can also be taken as the outside temperature which marks the beginning and end of the heating season. It can also be arrived at by trial by examining for actual operating plants the constant temperature from which the fuel consumptions vary in direct proportion. As a matter of fact all these methods were used to some extent in determining the 65° base for use with gas fuel. It happened that 65° was found to result from all the methods and was adopted as a base. The fact that the base for use with residential gas heating was thus carefully established probably accounts largely for the success with which the degree day has been applied to gas estimating.

Because the 65° base came into use first has led some to regard it as a standard and to look on other bases as makeshift variations from it. Also because the original definition was in terms of 65° some have considered that the use of 65° is essential to the use of the unit. Both beliefs are erroneous and unfortunate. The 65° base undoubtedly does have an especial merit when estimating residential gas consumptions, but may have no merit whatever for other fuels or other daily operating cycles of temperatures.

65° Base Correct for Residence Heating

It would be highly desirable if similar analysis could be applied to other fuels in order to establish their base temperatures with as high a degree of accuracy as with gas, but to date this has not been accomplished. Until such information is available the best practice seems to be to use the mean temperature actually maintained as the basis for estimating, even though it is obvious that this practice is not correct. For residential heating the 65° figure seems to be a reasonable one.

When properly used the degree day method of estimation has much to commend it. It will probably be a long time before enough detailed data are actually available for use to make it possible to estimate fuel or heat requirements in terms of the actual elements. Even if all necessary data were at hand, making an estimate would be a long and tedious process. The degree day offers a relatively quick and simple method which even now results in approximations sufficiently close for most purposes. The difficulty in its use arises because of attempting to apply it to estimates for which it was either never intended or in which experience has shown that it is not reliable.

WHEN USING THE DEGREE DAY—

1. **DON'T** attempt to apply the degree day to short-period estimates. Just how short is problematical but a thirty-day period is possibly the shortest from which reasonably good results can be expected. This also applies to the use of derivatives of the unit. The degree day is most useful and accurate for estimating seasonal requirements.

2. **DON'T** overlook the fact that the degree day depends for its accuracy on the balance of opposing tendencies, that the assumed efficiency of utilization is always a factor and that equally good results need not be expected in mild weather or seasons as against severe weather or seasons. Ridiculous results may be arrived at unless these factors are properly allowed for.

3. **DON'T** fail to take into account the maintained temperature during the period considered, including allowance for short hour heating.

4. **DON'T** attempt to make comparisons between different localities unless corrections for the lowest outside temperatures are made.

5. **DON'T** expect to make equally good predictions with different fuels unless enough is known about the operating characteristics. This is seldom true.

Smoke Eradication to Save the Health Value of Urban Sunshine‡

by FRED O. TONNEY, M.D., F.A.P.H.A., and
CLARENCE R. DeYOUNG†

Smoke eradication rather than smoke control is advocated. To attain this end the authors suggest three methods of heating—district heating, gas heating and electric heating.

LOSS of the shorter ultra-violet rays of sunshine, due to atmospheric pollution, is beginning to be recognized as a health problem of cities.

That the loss is constant and of sufficient proportions to be of health concern is indicated by recent studies in several American cities. In Chicago, both by spectographic and chemical methods, a decided loss of short rays and actinic[1] intensity was shown during most of the year and an unusually long period of low ultra-violet light in sunshine (7 months) was demonstrated. More recent studies in Chicago have shown that smoke is a very significant factor in the loss of actinic rays, even in summer the season of minimum combustion of fuel. In Baltimore, Shrader, Coblentz, and others reported a loss of about 50% in solar ultra-violet light as determined by actinic methods. In New York, Ives, in a study of sunshine measured by the photoelectric cell, showed a loss of 50% in visible light, without respect to ultra-violet light.

Efforts to abate the smoke of ordinary fuels to a sufficient degree to save the ultra-violet light of sunshine have thus far proved inadequate. The results have been apparent in greater visibility, cleanliness and economy of fuel rather than in material saving of ultra-violet light.

In Pittsburgh, an intensive 10-year program of smoke abatement by forced draft combustion methods succeeded in reducing the visible smoke due to unburned tarry matter, but increased the total deposit of dust particles in the air about 40%. Although the dust of ash particles, according to recent experiments, is somewhat less opaque to ultra-violet light than that of soot and tarry matter, it is nevertheless definitely opaque, and the greatly increased amount of ash dust would seem to offset the advantage of complete combustion by forced draft.

In Chicago one has only to look out over the downtown district from a loop tower or airplane on a bright summer day to realize the practical futility of control methods applied to the present combustion processes, with respect to conservation of ultra-violet light. As seen from above, even when combustion is at its minimum, a vast cloud hangs continually over the city, the massed contributions of thousands of stacks, each contributing a little, but each for the most part innocent of violation of any sane and reasonable anti-smoke regula-

‡ Read at a Joint Session of the Public Health Engineering and Industrial Hygiene Sections, American Public Health Association at the Fifty-ninth Annual Meeting, Fort Worth, Texas, October 30, 1930.

† Bureau of Laboratories and Research, Department of Health, Chicago, Illinois.

[1] Radiant rays of the shorter wave lengths in the spectrum.

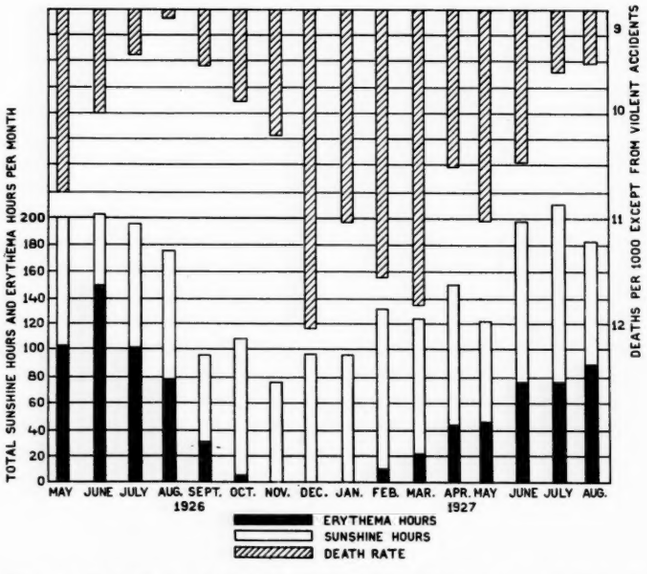

TOTAL SUNSHINE HOURS AND ERYTHEMA HOURS PER MONTH
DEATHS PER 1000 EXCEPT FROM VIOLENT ACCIDENTS
MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUNE JULY AUG.
1926
1927
ERYTHEMA HOURS
SUNSHINE HOURS
DEATH RATE

Fig. 1. Relation of total deaths to erythema hours of sunshine in Chicago, 1926-27.

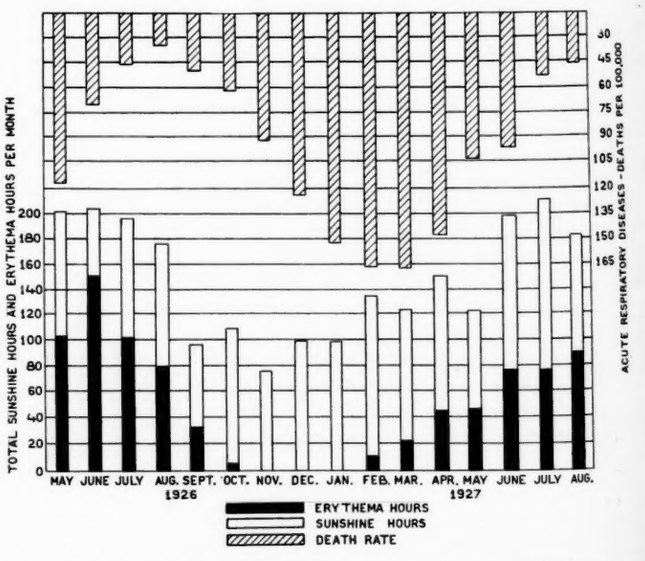

TOTAL SUNSHINE HOURS AND ERYTHEMA HOURS PER MONTH
ACUTE RESPIRATORY DISEASES - DEATHS PER 100,000
MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUNE JULY AUG.
1926
1927
ERYTHEMA HOURS
SUNSHINE HOURS
DEATH RATE

Fig. 2. Relation of deaths from acute respiratory diseases to erythema hours of sunshine in Chicago, 1926-27.

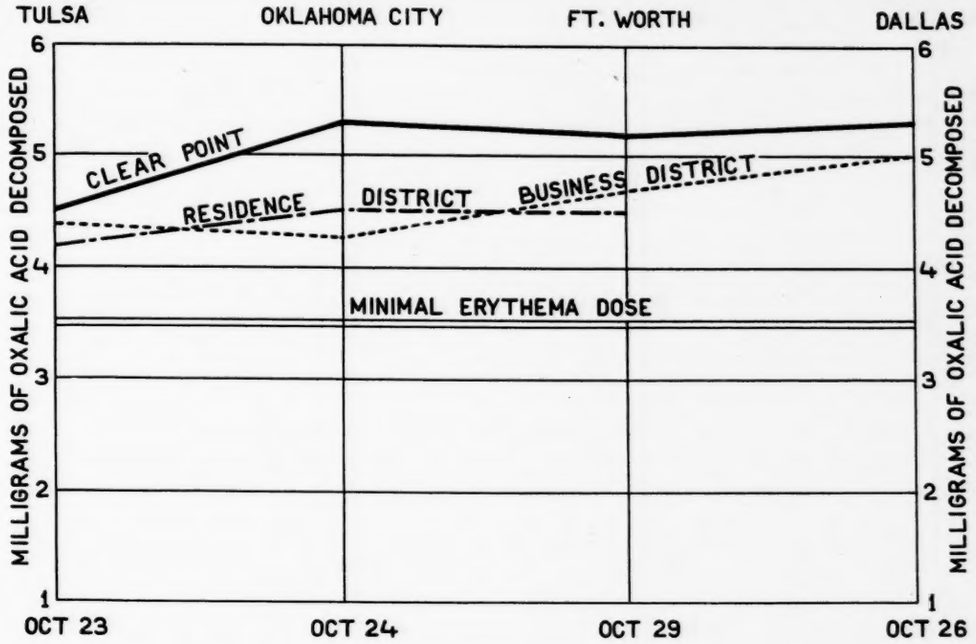


Fig. 3. Average hourly actinic intensity compared to clear point—10 a. m. to 4 p. m.

tion. It appears, therefore, that there is little hope of restoring the lost sunshine of cities by smoke control methods applied to the usual combustion processes.

A changed point of view is needed—a new objective to direct engineering thought toward a really effective solution of the problem as a whole, with its health aspects, as well as the esthetic and economic.

That objective, we believe, should be smoke eradication rather than smoke control, and its motivation should place foremost and above all other considerations the needs of the public health. Its slogan should be: "Sunshine of full actinic value, for urban as well as rural populations. (1) To assure normal growth of children; (2) To build sound, straight teeth and strong bones; (3) To eradicate rickets in infants, and (4) To help maintain resistance to those diseases which attack when vitality is low."

Figs. 1 and 2 are presented for study and critical anaylsis, rather than as a basis for any contention or conclusion. They offer data on the relation of (a) total deaths per month, and (b) deaths from acute respiratory disease per month, to (c) the total sunshine hours per month and (d) the erythema[2] hours of sunshine per month, during 1926-1927 in Chicago.

The striking feature of these charts is a remarkable correlation between respiratory disease deaths and erythema hours per month, which is not so obvious in any of the other relationships.

Low erythema hours are observed to be followed by high respiratory death rates with a lag of 1 to 2 months, and conversely the higher erythema hours per month are followed by correspondingly lower respiratory death rates, after a similar lag.

The Remedy

What promise of really effective smoke eradication may we find in the present state of knowledge to save the sunshine of cities? As a basis for constructive thought and discussion of the practical possibilities, we present three suggestions to the engineering profession, which, if they are sound, may help to direct the trend of development: (1) Steam heating from a central plant, serving a large district as a public utility; (2) Gas heating (3) Electric heating.

The Central Steam Heating Plant

The central steam heating plant serving groups of buildings through underground connections is familiar to all, but operating as a public utility over a radius of several miles, it is a relatively new development. Such plants appear to be well adapted to congested districts and apparently can compete successfully with individual heating plants, through greater economy in operating costs and larger purchasing power. From the standpoint of smoke abatement, a single stack, representing an efficient and well managed plant, is a welcome substitute for thousands of small plants, many of which are poorly equipped and carelessly operated. Even the minimal smoke accumulation of many small plants inevitably produces a smoke pall, while the same fuel, burned in a single well equipped and competently fired installation, should be relatively innocuous.

Mariemont, a suburb of Cincinnati, Ohio, illustrates this type of development in a newly built, well planned residence district. The central steam heating plant is now operating in several of the larger American cities, including Cleveland, Ohio, Detroit, Mich., Kansas City, Mo., St. Louis, Mo., Pittsburgh, Pa., and New York, N. Y. Progress toward smoke eradication by this method is necessarily slow and also it seems applicable only under special conditions. However, it deserves consideration as a potential method to be used in combination with the other available methods.

Gas Heating

The use of both artificial and natural gas in heating and industrial processes is now on the threshold of wide development. Pipe lines are being extended from the natural gas fields to the larger cities, including Chicago. Gas heating appliances may be readily fitted into existing boiler equipment and by reason of automatic con-

[2] Redness of skin produced by capillary congestion; sunburn.

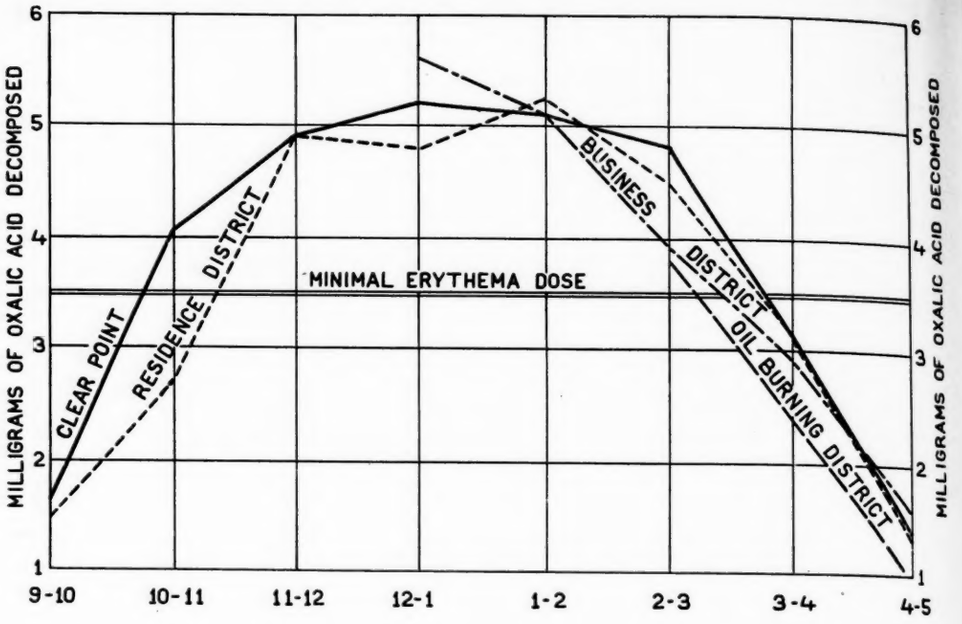


Fig. 4. Hourly actinic intensity compared to clear point.

trol and elimination of handling, hauling, and storage costs, gas is beginning to compete with other fuels.

Gas combustion is practically complete. The products are gaseous in nature and should contain no ash or other solid particles. Theoretically, at least, the burned effluent of gas combustion should not occlude the ultra-violet light of sunshine. Heretofore, however, there have been no data on this point.

To make a practical test of the possible screening effect upon the actinic light rays of atmospheric accumulations from gas combustion on a large scale, experiments were recently conducted by us in Tulsa and Oklahoma City, Okla., and in Fort Worth and Dallas, Tex., which are essentially gas heated cities. The actinic method was used.

Fig. 3 shows the average hourly actinic readings between 10 a.m. and 4 p.m. standard time, in the residence and business sections of the four cities on clear days, as compared to simultaneous readings in the nearby country, the latter locations being designated as "clear points." The maximum and minimum daily temperatures during the tests ranged from 42°-57° F. for Tulsa to 52°-76° F., for Dallas.

Fig. 4 illustrates the hourly differences between the urban and rural readings for a single day in Tulsa, Okla. The noticeable actinic loss between 10 a.m. in the residential district was apparently due to coal smoke from locomotives in a railroad yard to the windward. At the next hour the testing station was shifted to the other side of the railroad and thereafter readings closely approximating those of the clear point were obtained.

Both charts are to be considered in comparison with Fig. 5, representing the similar average findings by months in Chicago, especially from April to August

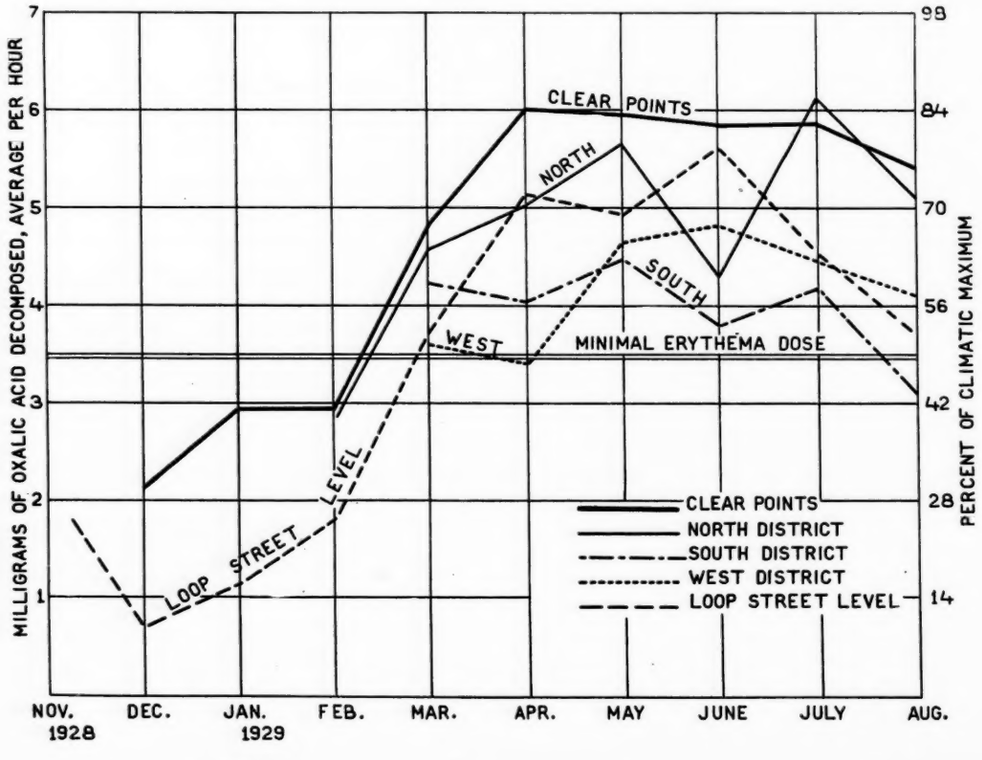


Fig. 5. Average actinic intensities for four city districts and for clear points. Hourly observations between 11 a. m. and 3 p. m.

inclusive, the season of minimal combustion for heating purposes.

In the southern cities the proportionate loss of actinic rays of erythemal intensity[3] from the smoke of gas combustion was very small compared to the loss in Chicago where coal is the principal fuel.

Of the gas heated cities, Oklahoma City showed the greatest actinic loss with an estimated percentage of about 80% of buildings heated by gas as compared to about 90% for Fort Worth, and 95% for the other two cities. The other fuel used is principally oil, but considerable coal is still used in Oklahoma City.

In Tulsa, an opportunity was presented to test an oil burning district (Fig. 4) and here a greater loss of actinic sunshine was demonstrated.

From the standpoint of smoke eradication, gas heating appears to offer greater promise of early relief than any of the other methods. It requires no revolutionary changes in building construction or heating equipment. It is equally applicable to old and new heating appliances. It can be placed in small and large plants alike. It may be extended rapidly, and brought to serve large areas within a relatively short time.

Possibly gas heating may not be the ideal ultimate solution of the smoke problems of cities, but it has the advantage of being already at hand. The possibilities of objectionable effects of accumulated gaseous products of combustion in the atmosphere are yet to be studied, but in any case immediate and decided improvement is certain and a means is available of bridging the gap between the present highly objectionable combustion methods and slowly evolving methods of the future.

[3] Actinic intensities of erythemal quality are those on or above the line indicating minimal erythemal dose.

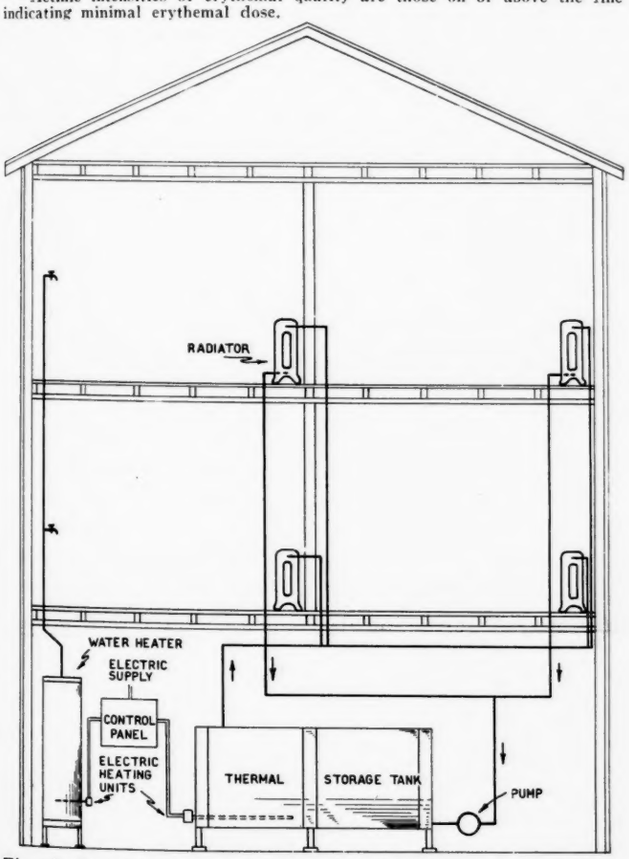


Fig. 6. Elevation of an electrically-heated home utilizing off-peak current.

Electric Heating

Until recently, the prospect of electric heating as the ideal goal of heating methods seemed far remote and to be thought of only for our children's sake. The idea is highly attractive—cleanliness, convenience, complete absence of smoke; fuel burned at a distance from the city and converted into current; hydroelectric power developed to its maximum possibilities. From a health aspect the picture is perfect, and apparently a trend consistent with previous development of electric light and power.

But the cost, we were advised, is prohibitive. The loss of energy in conversion of electric current into heat is greater than in its conversion to light and power. Coal cannot be burned at the mines unless an abundant water supply is at hand. Current cannot be carried more than 300 miles without excessive loss.

But who knows what compensatory saving there may be in electric heating, once it is established on an extended scale? Charges for fuel transportation by rail, unloading at the yard, reloading, cartage, repeated handling until it reaches thousands of individual plants, janitors shoveling coal and tending furnace, ashes to be hauled, repairs and maintenance, waste of fuel in smoke—all these leaks are costly. Perhaps in electric heating, as in gas heating, there would be added saving in quick availability—heat at once when and where needed, and saved at once where not needed—no loss in the building up or dying down of fires. Again, perhaps, there may be material saving in the interpeak usage of current.

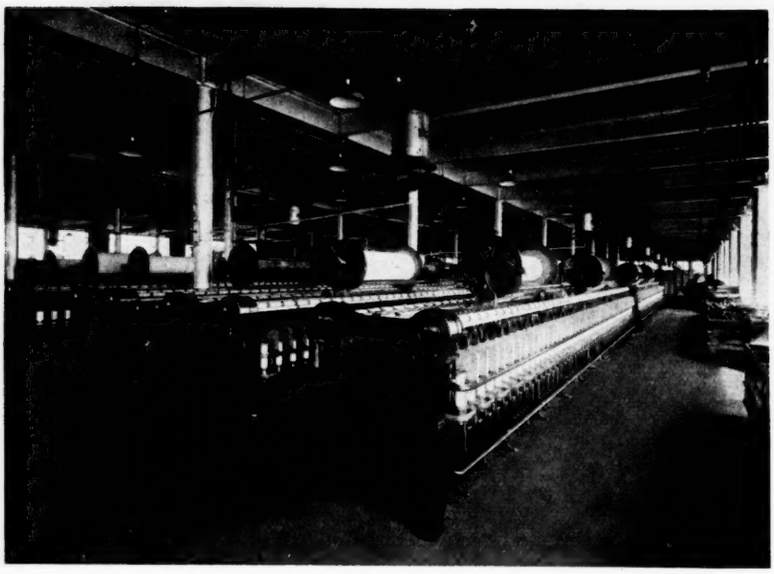
Fig. 6 shows a house-heating plan utilizing electric current at off peak hours, 11 p.m. to 6 a.m., to heat a well insulated tank of water under pressure to a temperature of 250° F. A community of the better type of homes, electrically heated by this method, is now developing in Fort Wayne, Ind., where rate concessions for off peak current have been allowed. In LaGrange, Ill., a suburb of Chicago, a single electrically heated home knocks at our door, awaiting similar rate concessions to make electric heating an actuality in the metropolitan area.

The Future

What a prospect—electric heating, gas heating and the central steam plant developing hand in hand, each seeking its most favorable outlet, according to its special fitness, electric heat to the finest suburban homes, gas heat to the city proper and to the industries, and central steam heating to the more congested districts. Smoke will be of the past.

Let us look for a moment toward the city of the future—clean with the cleanliness of health, with clean, invigorating air and undiminished sunshine, white buildings that stay white, clean lines, clean faces.

The health benefits of the country brought to the back yards of the most congested districts: Ruddy complexious like those of vacation days showing adequate dosage of ultra-violet light; healthy, normally growing children with even teeth, straight bones, and a high resistance to disease; a vigorous, active population of workers, producing effectively, living, working, enjoying—in an atmosphere of health.



Interior of modern twister room in cotton mill, showing suspended humidifiers.

Trends in the Cotton Textile Industry‡

By C. L. Emerson†

CERTAIN minor improvements are being made in conditions in the cotton textile industry among them being the elimination of difficulties of condensation. High humidities must be carried in certain departments and during cold weather the condensation on the roof and the large glass areas of side wall cause water drip.

Appreciation of the importance of various auxiliary services in obtaining better, larger, and more uniform production has grown remarkably in the last decade. The setting of proper humidity, the control of heat, the supplying of ample artificial illumination, the precise control of speed, the reduction of many forms of waste, have won their way by the most practical and decisive demonstrations. The net result has been that the conditions under which work is done have been placed definitely under the control of the manager, instead of being left to chance. By and large, he can set these conditions where his best judgment indicates, and then maintain them there and have records to tell him that they have been maintained. This group probably shows most clearly the handwriting of engineers in the industry.

To particularize, the temperature of mill space in winter had formerly been left to the judgment of various foremen, who regulated it by means of a hand valve. Busy with other duties, these men would disregard the heating system until uncomfortably hot; then would cut off steam entirely and leave it off until the room became too cold. These temperature fluctuations had a twofold disadvantage. First, the operatives suffered in efficiency, particularly from over-heating; second, processes were interfered with. Machine settings and oiling conditions were disarranged, but humidity conditions in particular were immediately upset. This can be readily appreciated on considering that with a temperature of 75° and a relative humidity of 69%, the air would contain 0.929 lb. of moisture per 1000 cu. ft. When the temperature dropped to 65°, substantially the same amount of moisture would be present, but the relative humidity would be 95%. The humidifier controls would operate, but it would take some time for proper conditions to be reestablished. Cotton processing is sensitive to humidity conditions, and these fluctuations would affect the operations adversely.

Automatic heat control has taken over this situation. The steam is turned off and on by a diaphragm valve operated by compressed air. This in turn is controlled by a pilot valve operated by a thermostat. Temperature is maintained, within one degree, and may be set at any desired point. The system pays its way in the savings at the coal pile of the heating plant, so the attendant advantages are obtained without appreciable cost.

Unit heaters should be mentioned as one of the newer developments in the heating system. These are replacing pipe-coil radiation to some extent, particularly in those departments where there is little lint or fly. Their fans create an air circulation which is particularly valuable where fan-type humidifier heads are not installed.

Trade practice in textiles is to allow 8½% by weight of water in goods purchased. As the output of weave mills is usually sold to someone else for further processing, any less water in the stock means a direct loss to the mill. This water cannot be suddenly injected in the cloth room, but has to find its way into the cotton even before it reaches the loom. Moreover, the work in all processes needs just the right amount of humidity to make it run best. The importance of humidity is readily recognized. In this climate it is necessary to supply moisture at practically all times, and mechanical systems have been in use for many years.

The atomizer system has been practically superseded by other types, and at this time most of the installations use heads with motor-operated fans, or the so-called "high-duty-head" systems. In certain mills, particularly in the weave sheds, central-station systems have been installed where the air is collected at one point, heated, humidified, and piped in ducts to numerous outlets.

‡ Extracts from a paper contributed to the Textile Division and presented at the semi-annual meeting of the American Society of Mechanical Engineers, Birmingham, Ala., April 20-23, 1931.

† Vice-president and chief engineer, Robert & Co., Inc., consulting engineers, Atlanta, Ga.

Humidor controls have been refined and improved to a point where their operation is quite satisfactory. In addition to the beneficial effects on mill operation, present-day humidifiers do considerable cooling in summer. It is not uncommon to have the mill interior 7° cooler than the outside atmosphere. With the central-station system, an even greater cooling effect can be obtained. The efficiency of workers, particularly in southern cotton mills, where the summers are long and hot, is enhanced by the circulation of cooled air.

The most recent improvement made is the application of humidification to picker rooms. This department has long defied the engineers because of the great volume of air circulated by the pickers themselves. It is particularly interesting that the solution of this problem came from a mill manager, and not from a humidification engineer.

The problem of heating and humidification has by no means been completely solved. Experimental work is now under way on small units which will both heat (or cool) and humidify. In fact, such units are on the market, but on account of excessive cost and other disadvantages from a cotton-mill standpoint, are not yet acceptable. This field appears to offer great possibilities for the future. Another effort which will offer remuneration is a study by the mills themselves of the precise degree of humidity which will give best results for a certain product and a certain grade and staple of cotton. Adjustments are at present made principally by rule of thumb.

District Heating Developments in Akron

Description of the distribution system of a middle west utility with particular reference to the use of condensation and demand meters.

By P. A. HYDE†

SINCE the original installation (1927) of district heating in the city of Akron, Ohio, the increase in load during 1928-29-30 has necessitated the addition of one boiler in 1929 and the present plans call for another boiler to be installed during 1931. This will make a total of four boilers with a manufacturer's rating of approximately 727 h.p. each. The boilers are good for 280% of rating. The peak load during the past season has been 140,000 lb. of steam per hr. All boilers are equipped with under-feed stokers, forced draft and induced draft fans, clinker grinders and water-cooled side walls. It is planned to have the fourth boiler ready for operation early in the fall of 1931. There is no electric generation at the steam plant and future plans do not call for any such installation, the idea being that the plant is built solely to give dependable heating service to the business district.

The original installation of mains consisted of approximately 5,000 lin. ft. as follows: Leaving the plant with a 15 in. main for an approximate distance of 1260 ft., then 1008 ft. of 14 in. main, 522 ft. of 12 in. main and 934 ft. of 10 in. main; laterals or extensions from the existing lines vary in size from 8 in. to 4 in. The pressure carried on the heating system at the present time is 120 lb. Since the original installation, approximately 15,000 ft. of main have been added to the system in order to take care of the rapidly expanding business. Slip expansion joints are used entirely for taking care of expansion and contraction. The entire system is of welded construction using extra heavy Vanstone flanges on standard weight steel nipples.

A typical standard steam service connection is illustrated. It will be noticed that no cast iron fittings of any kind are used and the contractor even perfected a strainer made of steel pipe and Vanstone flanges.

The accompanying map shows the general plan of the system, which is laid out with the idea of forming a loop. So far this has proved to be decidedly practical in operation and permits shutting off one block at a time, thus affecting but few customers.

A return line was installed with the original system but extensions from the main line are installed without a return. All return lines come back to the plant by gravity after they leave the customer's installation. The return main is built of extra heavy wrought iron pipe and from examination of the inside of the pipe it appears to be good for a number of years to come.

Steam is supplied to any class of service which can make use of it. Laundries, dry cleaning establishments and small pressing machines which formerly used other heating mediums are now using steam.

At the close of 1929 and early in 1930 there was an unusual building development in the city and all of the new buildings in the business district are using district steam for all their requirements. Some of the most notable buildings using the steam service are shown in the illustrations.

A photograph of the steam service and meter installation at the new Y. W. C. A. is also shown. This is especially interesting as it shows what can be done when care is taken with these connections.

The M. O'Neill Company department store, which was the first building served early in 1927, still ranks as the largest installed radiation load. The illustration gives a good idea of the great size of this building.

Condensation meters are used for metering customers' heating systems. On the high pressure or medium pressure service where steam jets or other appliances

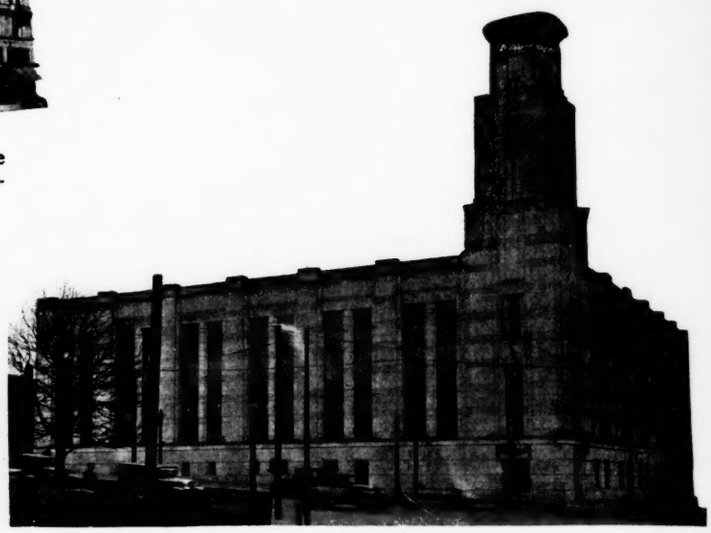
† Superintendent of Steam Distribution, Ohio Edison Company, Akron Division.

Some of the Notable Buildings in A

All of the new buildings in the business district of the Akron Division of the Ohio Edison Company. The illustrati

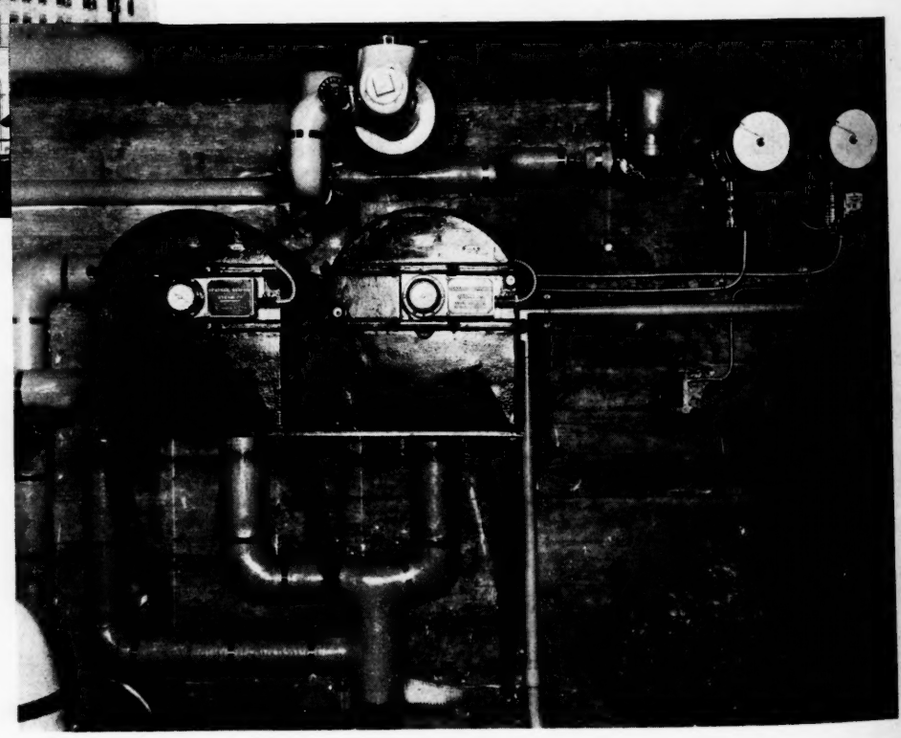
The original district steam system installed in 1927 consisted of only 5000 lineal feet of mains. Since that time approximately 15,000 feet of mains have been added. Steam is supplied to any class of service which can make use of it, and laundries, dry cleaning establishments and small pressing machines which formerly used other heating mediums are now using district steam.

The M. O'Neil Company department store has the largest installed radiation load of any of the district heated Akron buildings.



The publishing plant of the Times-Press shown above is serviced by the Ohio Edison Company.

The Y.W.C.A. Building in Akron is a large user of utility steam.

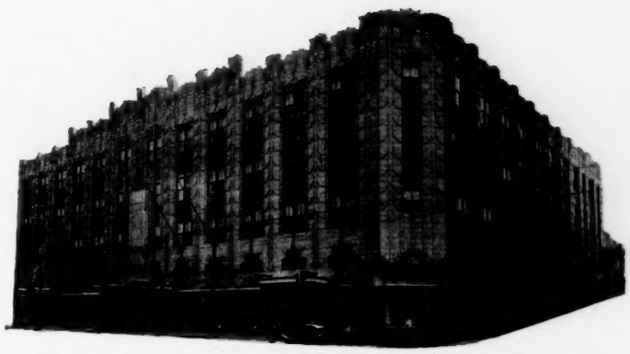


Detail of meter installation in the Y.W.C.A. Building

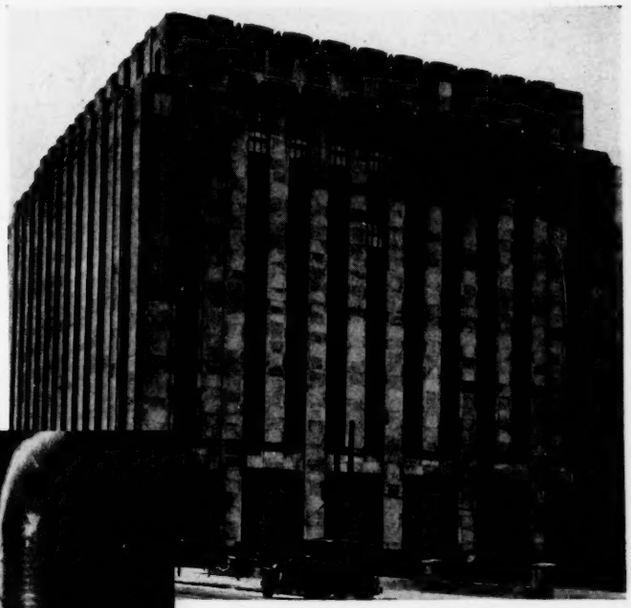
kron Heated by District Steam

city, erected in 1929 and 1930, are served by the
ions below show some of the outstanding examples.

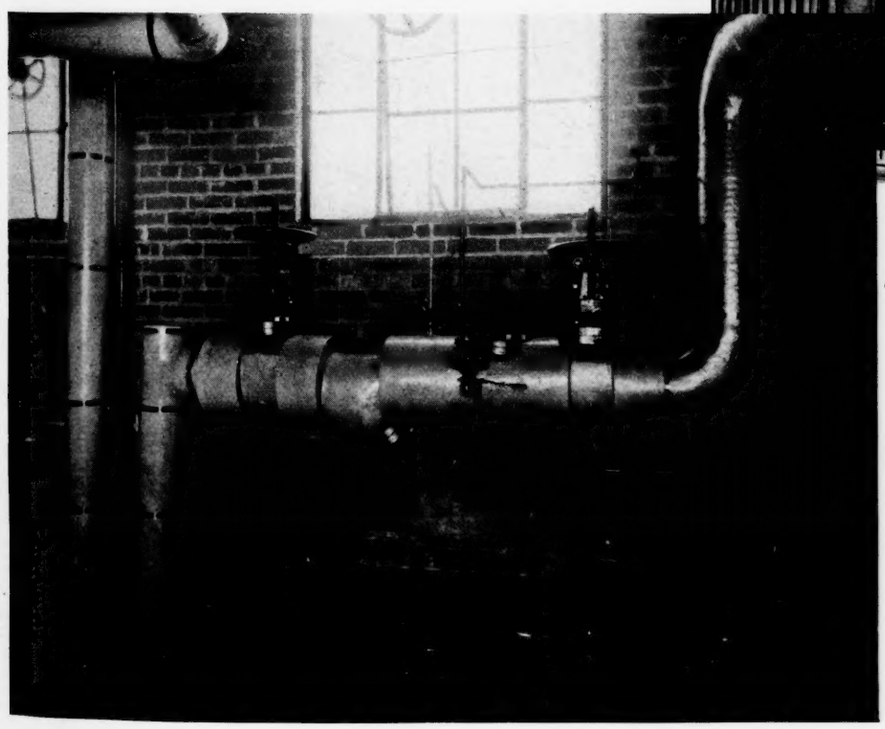
In the Mayflower Hotel, shown above, steam flow meters are installed in the kitchen and laundry, while condensation meters are used in the heating system and hot water tank.



The A. Polsky Store Building, Akron, Ohio, is heated by district steam.



The Ohio Bell Telephone Building shown above is a large user of district steam.

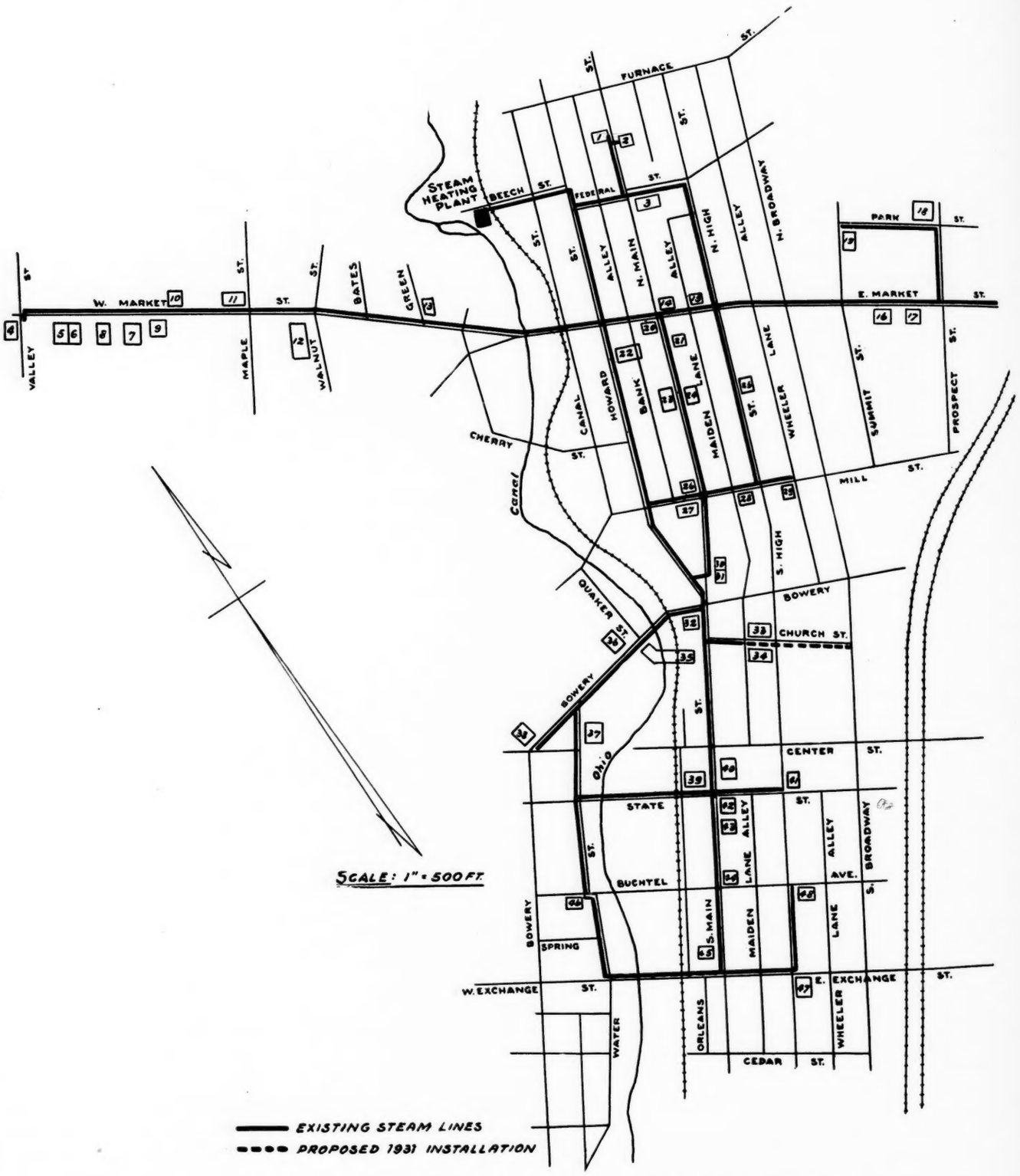


The illustration at the left shows a typical steam service connection.

are used, steam flow meters are installed. In some cases, such as the new Mayflower Hotel, both types are used. In this hotel steam flow meters are installed on the kitchen and on the laundry while condensation meters are used on the hot water tank and on the heating system. It may appear that an unusual amount of care has been used in metering this particular installation but it has been found extremely easy to settle disputes where meters are installed on individual lines and which furnish an actual check on the specific consumption.

Demand Meters

A number of electric contactor demand meters are installed, not with a view of making any particular study of demand at this time, but because they are a great help in settling disputed bills. The meter superintendent points out that when a demand chart with a solid black space for a seven day period is shown to a customer he immediately understands that something is wrong with the operation of his heating system. The demand meter seems to be far more satisfactory than the recording pressure gauge in such cases.



Plan of the distribution system of the Akron district heating plant.

Some Temperature Studies in Radiant Heated Rooms

The author's observations of the air temperature distribution in rooms heated by convection and by ceiling, floor and side wall radiant heating

By T. NAPIER ADLAM†

HAVING considered the various points relating to heat requirements and how the heat can be applied, we are now in a better position to consider what are the requisites of a good system of heating and ventilating. Dr. Leonard Hill, and also the Industrial Fatigue Research Board of England, laid it down that a good system should provide an air temperature at the foot level equal to that at the head level, if not greater. There should be a fair degree of air movement and the air should not smell stuffy and unpleasant. This compares with nature's provisions for heat supply where we find that rays from the sun, with the long waves reflected from the earth and surrounding objects, warm the lower strata of moist air from our feet upward and gives that ideal condition which our bodies require. The nearer we approach these conditions, the more closely we attain the ideal method of heating.

We have seen that, if an installation is to give the required degree of comfort and meet the physiological requirements of the body, a large percentage of the heat must be supplied as thermal radiations, and the relative humidity of the air should be maintained somewhere between 50% and 60%, preferably the latter.

† Consulting Engineer, Member of Institution of Heating and Ventilating Engineers, Great Britain.

Most of the heat should be given off by thermal radiations, with the remainder as convected heat.

Ordinary radiators may give off as little as 10% to 20% of their heat by thermal radiation and the remainder as convected heat, while with concealed heaters, unit heaters and warm-air systems we get no thermal radiation whatever, except the secondary action from the furniture. Since all the objects in a room are at a lower temperature than the surrounding air, and consequently at a lower temperature than our bodies, we get no supply of energy from these sources.

Fig. 1 illustrates diagrammatically the conditions we generally obtain with a concealed heater or a warm-air system. Assume that steam is turned on and a stream of warm air is introduced into the room from the grille or from the top of the concealed heaters. From concealed heaters the temperature of the air may be 130° to 150°, although I have actually measured the air temperature leaving the grilles as high as 190°.

With a warm-air system the inlet temperature may be as high as 180° to 200°. This warm air is not only detrimental to the system, but, having passed over a high temperature surface, it has become polluted, for when the air passes over a surface at high temperature the dust is broken down chemically and ammoniacal vapors given off. With steam radiators we get similar

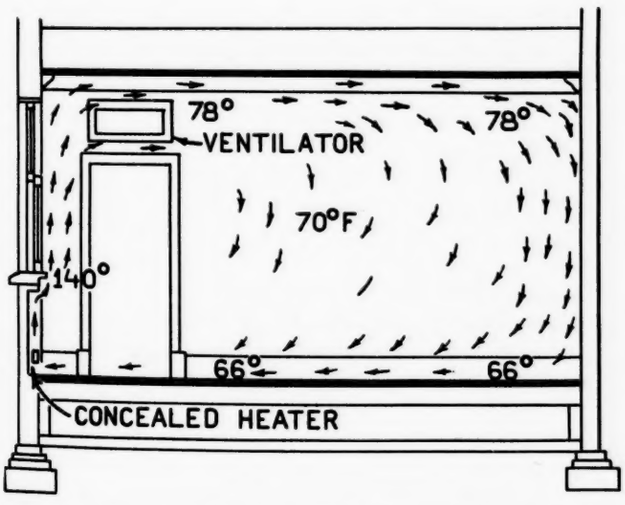


Fig. 1. Temperature distribution in a room heated with a concealed heater or a warm-air system.

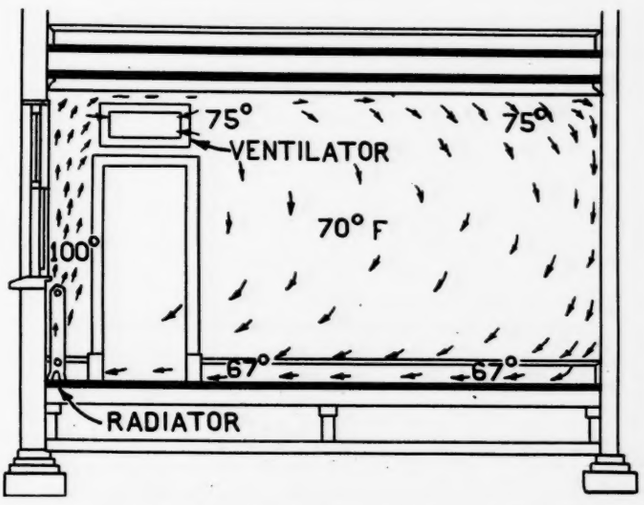


Fig. 2. Normal temperature distribution with a steam radiator. Average observations in rooms of 9 to 10 ft. in height.

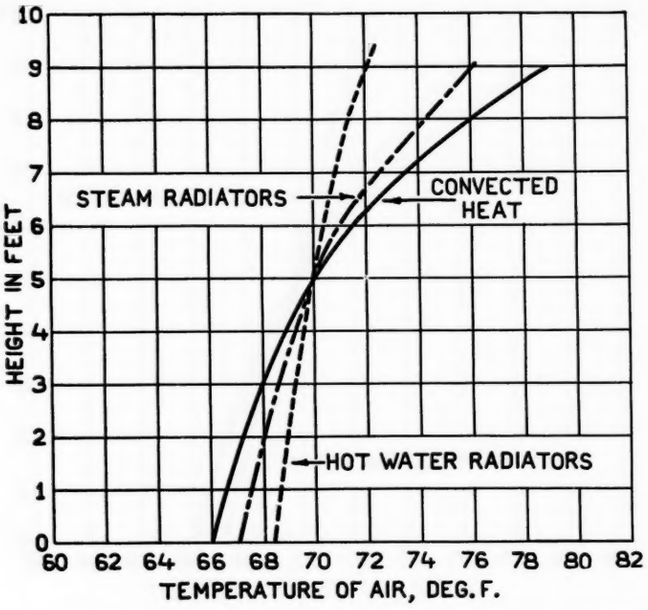


Fig. 3. Average reported temperatures at various heights for heating with radiators and convectors.

results, but the air leaving the top of the radiator will be 90° to 110°, depending on the room temperature.

In either case the warm air naturally rises to the ceiling and will remain there, giving up part of its heat to the cold ceiling, and should there be any outlet at the high level the warmest air will escape before being of further use. As more warm air rises from the source of supply the air at the ceiling, which does not escape, falls gradually. This continues until we get a series of layers at different temperatures. In other words, we have a temperature gradient from ceiling to floor.

The steepness of this temperature gradient will depend on the temperature of the air rising from the source, the heat loss from the room and the quantity of air which is circulating.

Temperature Difference of 6° to 14° Not Unusual With Convected Heat

When using steam pipes and radiators it is usual to get from 6° to 8° difference in temperature between the floor and the ceiling. With warm air or concealed heater I have found a difference of 10° to 14° to be quite common. Fig. 2 illustrates diagrammatically the normal conditions met with in a room heated by steam radiators. These are average observations in rooms from 9 ft. to 10 ft. high. For higher rooms the temperature at the ceiling will be correspondingly higher.

Fig. 3 shows average recorded temperatures at various heights for heating with radiators and convectors, and it will be clearly seen that the high temperature gradient means greater loss of heat. We find a warm stratum of air for breathing and for the head, with a cooler temperature for the feet, just the opposite to that required.

I have taken observations in many of the high buildings in this country and find that air is constantly passing through the ventilators over the doors into the corridors or passages at a temperature five or more degrees above the temperature of the air at the breathing line. This chimney effect in tall buildings is a bugbear to all heating engineers and architects because of the difficulty of being able to overcome its influence. The graduation of heating surfaces is only a partial remedy, for it does not hold good under all weather conditions.

Compare this with a building heated with thermal radiations where the air temperature at the high level varies only slightly from that at the breathing line. The result, as can be seen by Fig. 7, would be an almost constant temperature throughout the building.

Mean Surface Temperature Depends on Character of Surface

It has been computed that if the mean surface temperature all over a room is about 60° the room feels warm, regardless of the air temperature. This, however, depends on the character of the surface. If the surface is covered with tinfoil or a highly polished metal surface the results would be infinitely superior from a heating point of view than it would be if we had a dull black surface or even the usual papered surfaces.

Much has been written as to the best method of producing these heat rays, the relative virtues of ascending and descending rays, and the best temperature at which the surface should be maintained, but invariably it will be found that the respective advantages are illuminated according to the particular system advocated. Undoubtedly they all have advantages, and it is by correct discrimination that heating engineers can choose the best method for the particular problem in hand.

At present we will deal with each method diagrammatically, and later each system in use will be explained in detail. In Figs. 4, 5 and 6 we have indicated a room heated by thermal radiations with rays emitted from a heated floor, walls and ceiling respectively.

Fig. 4 shows a heated floor of a room made with any material ordinarily used for flooring, except material which is likely to become plastic with heat, such as wood blocks bedded in pitch, etc. Wood, stone, marble, concrete or other composite material may be used, and carpets may be laid on the floor without interference with the heat. In fact a carpet adds greatly to the comfort, for a heated floor covered with a thick carpet has given to the writer the best impression of real comfort of any heated room yet tried.

The required surface temperature of the floor varies with the kind of surface used and also with the exposure of the room. For instance, in testing out various materials I have found when trying white marble, which was to be used for the floor of Liverpool Cathedral, that with the polished white surface of the marble I required a surface temperature of 11° above the air temperature to give off a certain quantity of heat. I could obtain the same results with a surface temperature of 8° above the air temperature when the marble was covered with a thin coating of lamp black.

Higher Temperatures Desired in This Country Than in England

I should explain that in England it is found, generally speaking, that while 60° is a suitable air temperature with radiators and pipes, an equal feeling of comfort is obtainable at 56° to 58° with thermal radiations. In this country, however, it is desirable to have a higher room temperature than in England for several reasons.

In the first instance, people in this country evidently wear lighter undergarments and therefore rely more on artificial heat. Too, in this country they do less outdoor exercise and consequently the physiological heat generator will not function so readily as with people in England. The air, without doubt, is dryer, and consequently a higher temperature compensates for this.

Many years of living in a higher artificial temperature has had its effect upon the system, and as through the ages and process of evolution environment has changed life and custom, so I think in this country the metabolism of the average American is now demanding higher temperature to make up for the conditions to be met.

During cold weather this winter I have as a test condition been in my office and worked in perfect comfort while my colleagues have had to resort to their overcoats to keep themselves sufficiently warm, which proves that it is not so much the climate, but the gradual acquisition by continual use. I keep careful records and find that I require one or two degrees higher temperature than when I first came to this country.

Therefore, in dealing with the application of thermal radiations I am taking a basic temperature of 64°, as I find that this temperature with a relative humidity of 50° gives to my friends here a very real sense of comfort.

Referring to Fig. 4, it can be seen that we get from the heated floor a stream of thermal radiations passing upward over the whole area, or from that portion of the floor which we choose to heat.

Wood Floor Temperature to Be 16°-18° Above Indoor Air Temperature in Severe Weather

For maintaining the conditions stated above with an ordinary wood floor I find a surface temperature of 16° to 18° above the air temperature is necessary in extreme weather conditions. In milder weather 12° will suffice. This, however, is with an abnormal amount of glass exposure and with an exposed flat roof in addition. The range of temperatures recorded is indicated in Fig. 4 and also in Fig. 7.

It is interesting to note that in Fig. 4 the temperature 4 in. above the floor is but slightly higher than that at the breathing line, and so also is the air temperature 1 in. below the black portion of the ceiling. A portion of the ceiling was purposely made black to study the effect. The black surface absorbs the rays received from the floor and its temperature is raised slightly above the air temperature. Now the molecules of air in direct contact with the warmer surface receive heat by conduction, and immediately the molecules are set into vibration and rebound from the surface for a short distance, depending on the impulse received.

Radiometer Demonstrates Absorption by Black Surface

We may have a demonstration of this effect any time we stop at an optical store or a jeweler's, where a radiometer is on display. This instrument is usually constructed with two glass bulbs one above the other. In each of these bulbs there are four platinum vanes mounted on a light framework, which is pivoted on a needle point. One side of each vane is highly polished and the opposite side is coated with lamp black. The glass vessels are exhausted so that the air is very rarified and offers little resistance to movement. When a stream of rays impinges on the vanes they revolve so that the polished surfaces take the lead in the direction of the rotation. Energy is absorbed by the black, and reflected by the polished surfaces. The blackened surface naturally rises in temperature and the residual air is heated and, in terms of the kinetic theory, the air molecules striking the hot surface rebound with an augmented velocity. This reactive force on the black side causes the vanes to revolve.

With floors and ceilings, which are fixed, we get the effect of fixed surfaces, but with a continuation of discharging warm molecules of air driven away from the surfaces to a distance sufficient to absorb the energy.

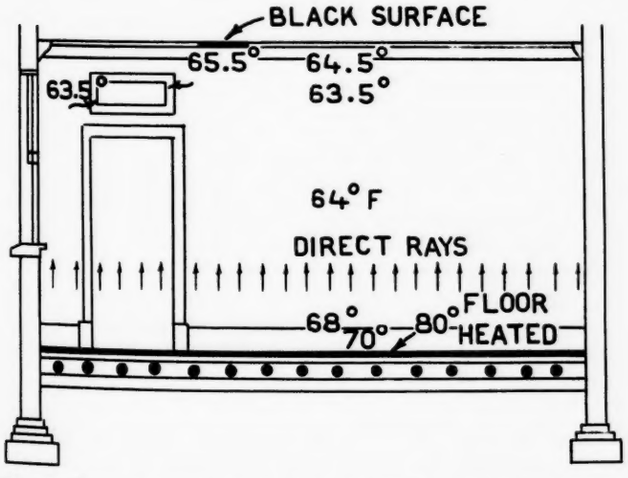


Fig. 4. Room with heated floor made of ordinary flooring material showing temperature distribution.

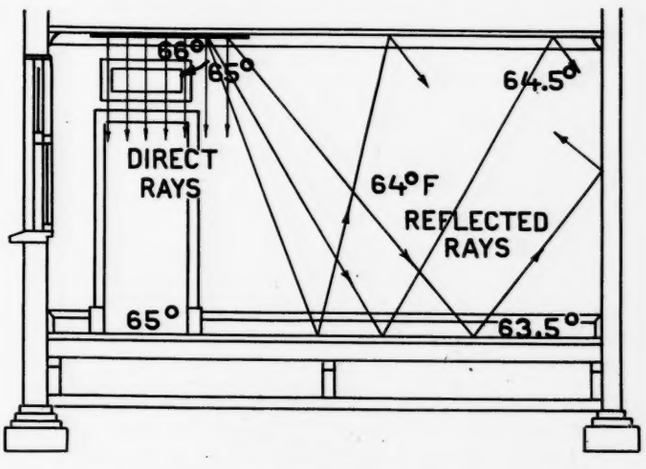


Fig. 5. Room warmed by a heated ceiling showing the manner in which radiant rays are reflected.

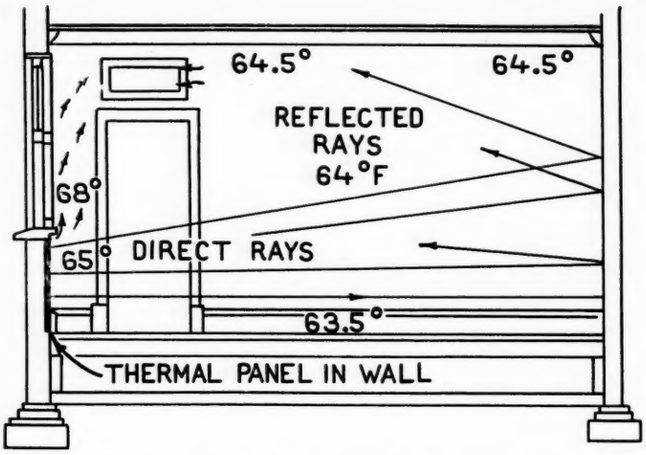


Fig. 6. Room heated with thermal radiations from heated surface on side wall.

Hence we get a slightly higher air temperature near all heating surfaces, for a distance varying with the force given to these molecules.

In Fig. 5 we have a room warmed by a heated ceiling. The rays descend from the ceiling, and if not intercepted by furniture or other obstacles will impinge on the floor and have the same effect on the floor as the heated floor (Fig. 4) has on the ceiling.

The disadvantage with this method is that anyone sitting at a desk or table will have his legs and feet screened from the rays, while the head and shoulders will receive the full shower of rays direct from the ceiling.

Radiant Heat from Side Walls Has Some Advantages Over Other Methods

Fig. 6 shows a room heated with thermal radiations given off from a heated surface placed on the side walls. When so placed we get a larger amount of convected heat than we do when either the floor or ceiling heating is used. On the other hand, we shall find in dealing with the details of the schemes that this method holds many virtues which the others do not.

The amount of convection obtained from the side wall surfaces amounts to about 40% to 50% of the total heat given off. The heat rays are given off horizontally, but with all unpolished surfaces we get an irregular surface, which has the property of sending out rays from all its facets. This means that rays are emitted at all angles, and with the reflected rays from other surfaces the room is filled with a shower of rays from all directions. A disadvantage of this method is that a large piece of furniture placed in front of the heated surface will annul its effect, but we should no more think of putting an article of furniture against the heating panel than we should of placing it so as to cover up the window or the door.

If we know the heating panel should be placed in a certain position and left exposed, why not have the courage of our convictions and say it must be so, in the same way as we would a window or an electric light. We can, of course, place the heating panel under the windows and, if sufficient surface can be installed, this makes a very admirable place, for the convected heat given off is well able to deal with the exposure of the window. The rays impinging on the opposite wall and those reflected will warm up the whole room, but care naturally must be taken to obtain full advantage of all the reflected rays, for by so doing great economy is effected.

Radiant Heating Approved by British Industrial Fatigue Research Board

With the small amount of convected heat given off, we obtain a current of warm air spreading itself over the ceiling which takes care of the heat loss through the ceiling, as it is apparent that with vertical radiant surfaces we do not get the rays impinging on the ceiling as we do in the other two systems. Speaking as a whole, however, it is the considered judgment of the British Industrial Fatigue Research Board that the thermal radiation method of heating gives a much more even temperature than does heating with radiators or with warm air.

This is even more true in this country than in England, for I find here, with the more extreme conditions and the different methods of construction, a greater variation in temperatures throughout the room with radiator heating than is the case in England.

With very large rooms with a high exposure factor it would add considerably to the comfort to have a combination of floor and wall heating. It is invariably found that the occupants in such a place will complain of cold feet even though the air is overheated. This is due to the screening effect of all heat, either radiant or convected, the cold floor, and no doubt a slow current of cool air moving over the whole floor surface. If the floor was raised to a temperature of say 6° to 8° above the air temperature and the additional heat added by wall panels the effect would be ideal.

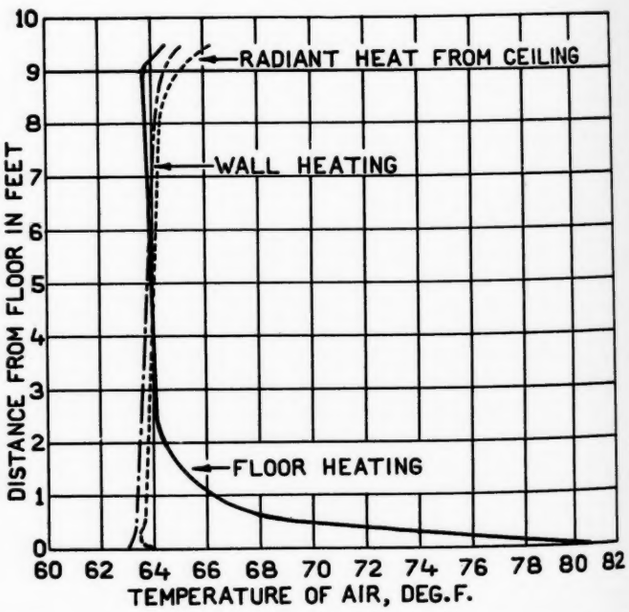


Fig. 7. Comparison of results with radiant heating from ceiling as compared with wall and floor radiant heating.

Radiant Heating Studied in Britain by Using Scaled Models

ACCORDING to a recent issue of a well-known British technical journal*, no direct comparison between radiant heating scientifically applied and air heating is possible, for air temperature is not a complete guide to comfort. The article in which this statement appears is a rather extensive abstract of a paper presented before an English Engineering society.‡

The data of Rubner on the heat lost by sedentary persons in warm surroundings is restated and it is affirmed that a considerable portion of this loss is by radiation. On this basis air temperature alone cannot define or measure comfort, and the conception, so often occurring in British papers, that the rate of heat loss from a body is the true measure is reviewed. It is interesting to learn also that an instrument is now commercially available for controlling heating based on this principle.

Under a sub-heading of *Radiation* the following statements are made:

"The ideal system must possess the following properties:

(1) The surface temperature of the units must be reasonably high (but not high enough to "burn" the air or dust contained therein) in order to

(a) Obtain a large percentage of radation

(b) Permit the intensity of radiation to be varied over a wide range

(c) Limit the area of surface required.

(2) The surface must have a high emissivity.

(3) The units must be of such a nature that the direction of the radiation emitted can be controlled in order that the distribution may be perfected and modified to suit conditions. It is also important that as little radiation as possible should be allowed to fall on external walls.

(4) The system must not be sluggish in operation. The rate of heating and cooling of the units should not be sufficiently great to cause rapid fluctuations in radiation intensity; it must be possible to obtain a state of comfort with rapidity.

(5) The units must not depend for their effect on raising the temperature of the structure of the building, as this not only introduces a high degree of sluggishness, but greatly increases the heat loss from the building."

A Morganite Radiation System is mentioned and it is said that it employs "a number of panels 2 ft. x 1 ft., operated at a moderately high temperature" and that these can be mounted in any position and at any angle to the surface of a wall or ceiling. Details of the shape, construction or material of these panels are not included, but from illustrations accompanying the article it seems that they are cubical in shape. The method of applying heat to the panels is also not shown in detail.

Equations are included to enable calculation of the intensity of the radiant heat at any distance from the radiator and making an angle to its surface.

* "The Heating and Ventilating Engineer," London, January, 1931, page 211.

‡ "Some Notes on the Theory of Radiant Heating," by C. G. Heys Hallett, paper of the Institution of Heating and Ventilating Engineers, London.

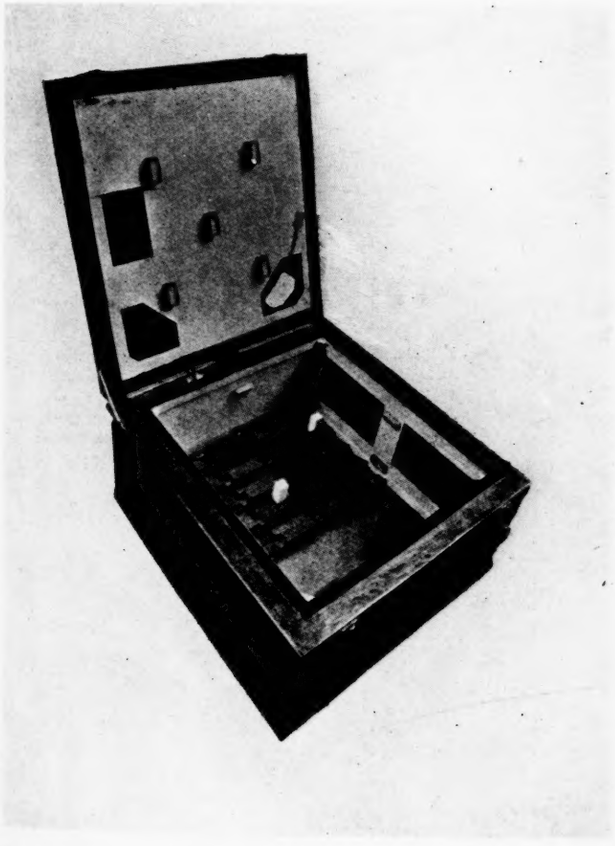


Fig. 1. Scaled model for studying arrangement of radiators.

Fig. 2. A schoolroom with radiant heating.

Possibly the most interesting feature of the article is the use of a scaled model, with prisms to represent the occupants, on which prisms visible light was allowed to fall. Since radiant heat travels in the same way as visible light, the effects of the location of the radiators could be thus studied. In the particular model studied a height of 7 ft. 6 in. seemed desirable.

Fig. 2 is a photograph of a schoolroom in which this method of heating was installed. The thermostat located on the teacher's desk can be seen as can also the radiators. Fig. 1 is a view of a scaled model used in studying the arrangement of the radiators. Note the two white prisms used to represent persons. Fig. 3 shows the result of the study as obtained. The upper sketch shows in each case the location of the heaters. At A, where the heaters were located near the floor, the seats cut off most of the rays. At B, the heaters were located on the ceiling, and the illumination on the tops of the prisms is clearly shown. Note the improvement when the radiators were shifted to a height of 7 ft. 6 in. above the floor. The arrangement shown at E is the one finally selected.

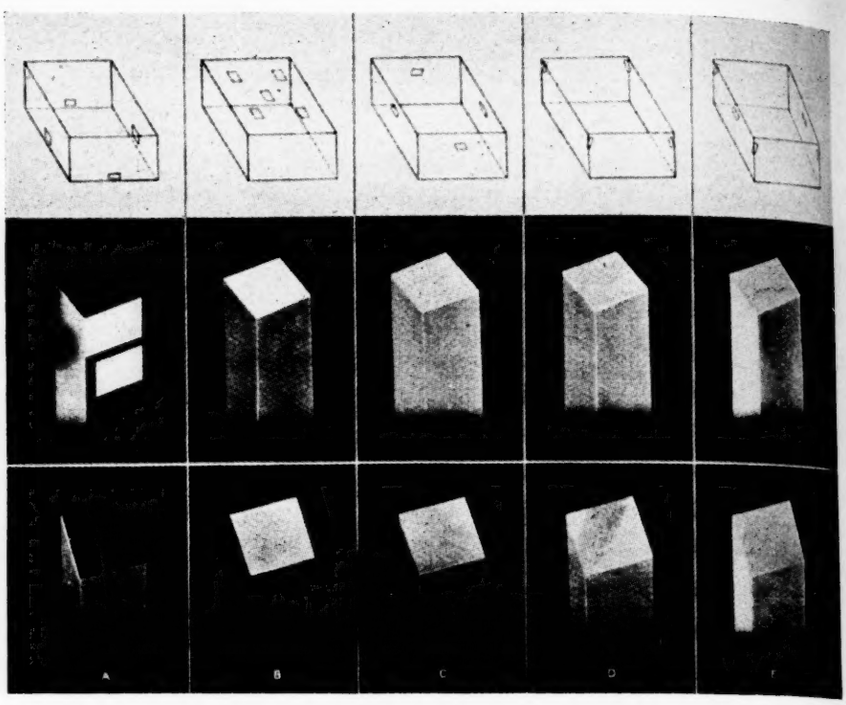


Fig. 3. Results of the study. The upper sketch shows location of heaters.

The following statement is significant: "It must be thoroughly understood that no direct comparison between radiant heating scientifically applied and air heating is possible, for air temperature is not a complete guide to comfort. The comparison would, therefore, be between a system which is maintaining a steady state of comfort, and one which is not."

Another illustration shows a schoolroom heated by a combination of wall panel and overhead panels installed on the lighting fixtures. The heated space is stated to be 100 ft. x 36 ft. x 26 ft., or 93,600 cu. ft. The installed capacity is apparently 30 kw. of connected load. This corresponds to 102,450 B.t.u. per hr. at full load. Thus the installed heating capacity is

$$\frac{102{,}450}{93{,}600} = 1.1$$

(approximately) B.t.u. per hr. per cu. ft. of heated space. Contrast this with American practice in convective heating where a common standard is one square foot of radiator per 60 to 100 cu. ft. of heated space. This corresponds to

$$\frac{240}{60} \text{ to } \frac{240}{100}$$

or 4.0 to 2.4 B.t.u. per hr. per cu. ft of heated space. The cause of such a sharp contrast would be interesting as it seems too wide a discrepancy to attribute entirely to climatic conditions at full load.

Shopping of Bids

By JOHN R. COOPER†

PRESENT unsatisfactory conditions now existing in the heating industry, most specifically among the unit heater manufacturers, would cease to exist if different and more business-like methods were adopted. The unit heater manufacturers themselves are primarily responsible for their own troubles resulting from their apparent willingness to accept orders below cost. While the existing period of stress in the industrial world may at this time justify smaller profits than normally, and possibly a small operating loss in order to help keep manufacturing and sales organizations intact, present extreme practices are not by any means justified.

The submission of different prices for the same equipment varying with the pressure brought to bear on the seller is not only unethical practice but causes immediate financial loss and lowers the prestige of the trade. In effect, such a practice results in taking advantage of confidence placed in the seller by his business friends who are penalized for the benefit of shoppers. Price reductions should be either in the form of changes of list prices or trade discounts, and the policy laid down rigidly adhered to. In no other way can the present orgy of price cutting and finan-

†Eastern Branch Manager, Thermal Units Manufacturing Company.

cial loss be stopped. It pays in any business to let the other fellow make a little money once in a while.

Engineers Should Request Alternate Figures Depending on Equipment

If unit heater manufacturers would make their original quotation their final word and abide by it, and if engineers would assist them by making some changes in their present methods of writing specifications, the present evils would largely be removed. The change suggested for engineers is that they request alternate figures from heating contractors depending on the equipment to be used.

While this may apply to all equipment involved, it specifically should be used in connection with unit heater specifications, provided consideration on a basis other than price is in order. The naming of three or more unit heaters and the "or equal" clause in the specifications results in the door being thrown wide open to the heating contractor who promptly attempts to unearth the manufacturer who will quote the lowest price.

Naturally, under the "or equal" clause the line of least resistance for the engineer is to accept the contractor's recommendation under a blanket guarantee. This means the contractor will be paying the minimum price, and as a rule gives the minimum result for satisfactory performance on the job to the owner.

The principal trouble lies in the assumption that an industrial building is a vast container into which we can pour heat more or less indiscriminately and obtain satisfactory results. The very fact that we are selling unit heaters today, replacing old style wall coils and direct radiation with an equivalent amount of heat, proves without question the fallacy of such reasoning, and yet that is what we are up against now so long as the specifications are worded in their present manner.

While there is no question that an honest difference of opinion exists as to the relative merits of this or that product, from a performance and durability standpoint, there can be little, if any, debate that any question of industrial heating, via the unit heater route, is in reality a problem of warm-air transportation. From this it logically follows that volumes, face velocities, and delivered air temperatures, must also be given a proper consideration in addition to B.t.u. output if the proper answer to any particular problem is to be given from a performance standpoint.

Since the very life of this unit heater business depends upon the satisfaction of the user, the importance of this simple fact warrants consideration by not only the manufacturer but also by the engineer upon whose expert advice the owner relies.

Too Much Buying Solely on Price Basis

"The problem must be solved rather than some money must be saved" would be a good slogan for the unit heater industry to adopt so that satisfaction to the consumer can be assured. It would be considered absurd for any company today wishing to buy motor vehicles to include Cadillacs, Buicks and Fords in the same specifications and ask for bids on a price basis. In effect, however, that is just what is now being done in the heating industry and it is without question the reason why contractors are placed in their present position.

Taking up again the subject of specifications, it can be pointed out that the manufacturers can be blamed as much as the engineers for present conditions. Both classes are to blame, and the manufacturer more so than the engineer, especially in not knowing or refusing to admit that his particular product has its relative merits depending upon performance and price.

The idea should be sold to the specifying engineer that he should place himself in the position of a doctor who prescribes for his patients somewhat as follows:

1. This is the medicine that will in all probability not only make you well but, if intelligently used, will keep you in that condition indefinitely. Of course its initial cost is rather high but it is worth it.

2. Here is something that will probably give you temporary relief in any case, but will never entirely cure you.

3. Here is something also that probably will not kill you but will never make you very happy, although its cheapness, of course, recommends it.

The proper answer to the problem will depend upon the condition of the case and the money available, and is properly a matter for the owner, with the advice of the engineer, to decide rather than the heating contractor who is generally looking at the subject from an initial cost basis only.

Under the present method the doctor is writing several prescriptions, handing them to the druggist to be filled and giving him permission to use his own judgment. The druggist, unless he is an unusual one, would quite naturally recommend the product he can sell to the best advantage regardless of whether or not it meets the requirements in full, so long as it apparently does.

Contract Could Be Awarded on Basis of Equipment Supplied

If the method of alternate bids would be followed out, it would permit the engineer to specify without limitation such equipment as he felt it in order to consider, and would enable him to discuss the question of relative values intelligently with the owners. The engineer and owner would, with all prices before them, then definitely award the contract with specific instructions as to what equipment should be supplied. Such a method is fair to all parties and would permit sales to be made dependent upon the ability of the sales force properly to present the merits of its products.

It would limit the contention of heating contractors that they have to use the lowest possible figure in order to have a chance to obtain the contract, because all would be bidding on the same basis. It would also mean raising the standards of selling and the almost complete elimination of present "shopping tours" which result in no profit to any manufacturer.

What Thickness Insulation?

By PAUL D. CLOSE

The accompanying article is divided into three parts. Part I contains Mr. Close's reply to the recent discussion[2] of his previous articles.[1] Part II takes up the subject of the economic thickness of insulation for buildings heated with gas, while Part III is an outline of special conditions where insulation is used in place of other materials, and where the method of installation is a factor.

Part I—Discussion

A SERIES of articles by the writer relative to the thickness of insulation for building construction has appeared in recent issues of this publication[1]. These articles proposed two slightly different methods, the first of which was based on the overall return on the investment for the entire thickness of insulation installed, and the second, on the instantaneous return on the investment for the final increment of thickness. Formula A for coal and formula E for oil were based on the first method, and formula B for coal and formula F for oil were based on the second method. Although both methods were discussed, preference was expressed for formulae A and E based on the overall return on the investment.

A criticism of this preference, and also of certain seemingly unimportant factors, was presented recently[2] by the staff manager of the engineering department of an insulation manufacturer, in which it was alleged that the formulae involving the second basis (the instantaneous return on the final increment of thickness), which he incidentally sought to prove was the more logical one to use, was similar to a formula introduced by the late L. B. McMillan. Inasmuch as the writer presented formulae for both methods, it appears that the analysis submitted was intended primarily to question or denounce the one and to substantiate or affirm the other, but the discussion seemed to be almost entirely the former, with very little credit given for that to which the correspondent evidently subscribed. It should be pointed out that at the time these articles were prepared the writer was not familiar with the McMillan formula, although formulae B and F apparently are similar to this formula.

While it is obvious that the correspondent and the writer entertain a somewhat different point of view on many phases of the subject, it is also apparent that the intent of the writer's articles and formulae was misunderstood. The following statement should therefore be noted:

> The selection of insulating materials for building construction, has, up to the present time, been largely arbitrary, or a matter of guess-work. It was the purpose of the formulae presented to provide some *simple, logical* basis for arriving at the thickness of thermal building insulation.

Although two types of formulae were presented by the writer for estimating insulation thickness, the one was recommended, as previously stated. But the formulae recommended would have been of no more value than the customary process of guessing if they had not been derived on some rational basis. The principle upon which formulae A and E were derived is as follows:

> The return on the investment is equal to the monetary value of the savings derived from the insulation, divided by the cost of the insulation. Since these savings are a function of the insulation thickness (and other factors), the thickness of insulation can be determined by fixing the return on the investment and reversing the solution of the problem.

The thickness of insulation obtained by means of the formulae thus derived (formulae A and E) is that thickness which will pay the specified overall return on the investment. The logic of this procedure was explained[3]. The same result, however, could have been obtained by means of formulae B or F by making the proper selection of the return on the investment for the final increment of thickness. The relation between the overall return on the investment and the instantaneous return on the investment for the final increment

[1] *Economics of Thermal Building Insulation*, HEATING AND VENTILATING, August, 1930, page 70: October, 1930, page 73; *Choosing the Thickness of Insulation for Oil Heated Buildings*, HEATING AND VENTILATING, March, 1931, page 65.

[2] *Calculating the Proper Thickness of Insulation*, HEATING AND VENTILATING, April, 1931, page 92.

[3] HEATING AND VENTILATING, August, 1930, page 70.

of thickness was given by the writer in a later issue,[4] in connection with the formulae for oil fuel.

No claim has been made that formulae A or E will give the most economical thickness in every case, but it is maintained that these formulae will give a reasonable result and are therefore useful. Whether or not the basis recommended by the writer (to which the correspondent takes exception) is the most accurate or scientific upon which to select insulation, does not alter the fact that it is a basis for so doing, and one which, it is believed, will be generally acceptable, except perhaps where the established policies of an organization must be maintained.

Assumptions

The correspondent called attention to the fact that a constant of 4.2 was used in the original presentation of formula A in an architectural publication[5], but that a value of 3.23 was used for the same constant in a later article in this publication[6], and states that "the author gives no reason for the revision of his opinion as to what he might assume as constant average values for the above factors, neither does he explain why these values may be assumed as generally representative of average universal conditions." The second article had no bearing on the first, and consequently no reference to it or comparison with it was necessary. Hence, there was no reason to explain the "revision of his opinion." It is quite obvious, however, that the assumed values for deriving this constant can be replaced by any values the engineer might choose to apply in the light of his knowledge of the subject by making use of equation (8) in the writer's first article in this publication[7]. It therefore seems almost incredible that this point should have been raised. The values used for obtaining the constant of 3.23 were[8] 60% and 13,000 B.t.u. per lb. instead of 50% and 12,000 B.t.u. per lb. as in this first article, and these changes were made because more recent information indicated that the values used in the second article were more nearly correct for average conditions. It is obvious that these factors may be extremely variable, but as previously stated, the engineer can substitute specific data for the assumed average values by using equation (8). The correspondent stated that by using the constant 4.2 the thickness obtained is 55% greater than by using the constant 3.23. It is regrettable that he chose to express the difference in such terms as would show the greatest discrepancy. If the thickness obtained by applying the constant 4.2 had been used as the divisor, and the result expressed accordingly, the difference would have been 35.6%. Regardless of these differences, the result is much more accurate than the prevalent practice of guessing the thickness of insulation required. The correspondent neglected to mention that there would also have been a difference in the thickness of insulation obtained if different constants had been applied to formula B to which he apparently subscribes, since the same factors are used in this formula.

The correspondent stated that in his opinion "these assumptions cannot be justified, and should not be recommended for adoption by the engineering profession," but failed to offer any constructive suggestions concerning the correct values to use. The values assumed by the writer were not claimed to be absolute or final, but were merely introduced to simplify a formula which, without these factors, contained eight variables. However, the assumptions used in the articles in this publication which the correspondent stated "cannot be justified" were based on data contained in a standard handbook[9]. It should be remembered, however, that there is danger in using specific figures for efficiencies and calorific values, for a biased critic can prove whatever figures are used to be incorrect.

General vs. Specific Formulae

In the articles in question, separate formulae were given for different fuels and another seemingly trivial criticism of this practice was made, namely, that "such variations of one basic formula can be of no beneficial service to the profession." These variations are not as simple as one might infer from this statement. Furthermore, it is obvious that a problem involving any specific type of fuel can more readily be solved by means of a formula intended specifically for that fuel than by means of a general formula. It would be equally logical to argue that heat transmission tables for various types of wall or roof construction are of "no beneficial service to the profession" because the same result can be obtained by substituting the proper values in a general formula. In a statement which follows, it is inferred that approximate results are obtained by this procedure, but the fact of the matter is that the results will be identical whether a general formula or a specific formula is used, if the proper substitutions are made.

The correspondent contested the statement that formula A is more simple than formula B but apparently endeavored to discredit the idea, insignificant as this point may be. The fact remains, however, that formula B involves a radical whereas formula A does not.

Optimum Thickness

The correspondent stated that "*All authorities agree* that the most economical or optimum thickness of insulation for use in any case is that thickness which will result in a maximum net monetary saving." While this statement may be approximately correct, no information was given as to who these authorities might be. Unfortunately, these matters have not, to the writer's knowl-

[4] HEATING AND VENTILATING, March, 1931. Page 65.

[5] American Architect, March, 1930.

[6] HEATING AND VENTILATING, August, 1930, page 70.

[7] HEATING AND VENTILATING, August, 1930, page 70.

[8] HEATING AND VENTILATING, August, 1930, page 71.

[9] A. S. H. V. E. Guide, 1931.

edge, been settled by agreement of the so-called "authorities." Although there may be some difference of opinion on the subject, the writer believes that the most economical thickness of insulation may be considered as that thickness at which the sum of the cost of heat and the cost of insulation for any specified period is a minimum, which perhaps agrees in substance with the correspondent's definition.

In estimating the cost of insulation for any period of time, various factors must be considered, including interest on investment, depreciation, maintenance, insurance, allowance for radiation saving, etc. The exact values of some of these factors may in many cases be doubtful. Consequently, to the extent that the determination of the cost of insulation is arbitrary will the determination of the economic thickness be arbitrary. But such refinements in solving insulation problems will no doubt to many individuals seem ridiculous, and while a procedure is desirable which will in a large measure eliminate guess-work, the writer does not believe that meticulous exactitude is warranted in the case of building insulation problems where many somewhat indefinite factors usually are involved. It is therefore believed that the methods advanced by the writer will be generally satisfactory for the solution of these problems, even though the thickness thus determined may not be theoretically accurate to the thousandth of an inch.

It was stated by the correspondent that "The optimum thickness is determined *exactly* by formula B which determines that thickness of insulation for which the final increment will pay the required return on the additional cost of that increment." This statement appears to be inconsistent. Although the second part of it seems to be correct, the first does not because formula B will not give the optimum thickness in the form in which it was submitted, since the optimum thickness does not take into consideration the return on either the final increment of thickness or the overall thickness.

The correspondent stated that formula B is similar to a formula presented by the late L. B. McMillan, which appears to be correct in that it is similar. The essential difference, however, is that formula B involves the return on the final increment of thickness, as previously stated, whereas the McMillan formula referred to apparently does not. It is also interesting to note that the McMillan formula was not intended to cover the field of heat transfer through building materials, as indicated by the following statement in the introduction to the paper to which the correspondent refers:[10]

"The particular field of this research is the literature referring to heat transfer through insulation in the temperature range between the refrigeration field on the one hand and the refractories field on the other, with the specific exception of literature pertaining to heat transfer through building materials. . . ."

This statement is further borne out by the fact that the McMillan formula referred to gives factors for 8760 hr. per year,[11] instead of the usual 5040 hr., or thereabouts, for the heating season in northern latitudes. For this reason, the writer believes that his were the first published formulae intended to deal specifically with the determination of the proper thickness of thermal insulation for the building field. A formula for the refrigerating field was originally presented by Percy Nicholls.[12]

Return on Investment

Since with formulae A and E it is necessary to assume some return on the investment to solve the problem, a value of 20% was chosen by the writer, and a discussion introduced to justify the selection of this value. It was stated that "It will be found from an analysis of a large number of problems that the thickness determined from formula A, based on an overall return of 20%, when substituted in formula B, will give an instantaneonus return between 9% and 10%, when solving for I_r (the instantaneous return at the final increment)." In a specific example cited, this relationship was correct, but a formula showing the relation between the overall return and the instantaneous return was presented[13] which indicated clearly that a variable relationship between the two returns exists. The correspondent apparently was familiar with the contents of this article as a reference to it was made in a footnote[14] of his review. There was, however, no intention of contending that a fixed relationship between the two "returns" exists, as implied by the correspondent, although it is conceded that this impression might have been obtained from the foregoing quotation. Had this point been clear, it is possible that the correspondent would have been spared the necessity of writing the lengthy discussion in question, since a large part of it concerned this subject.

The writer does not subscribe to the statement by the correspondent that "The use of insulation cannot be shown to pay for itself if the return on the final increment is set at a point where it is equal to or higher than the overall return." The overall return is always greater than the instantaneous return on the *final* increment of thickness, at the thickness upon which the overall return was based. For any given thickness of insulation the instantaneous return on the initial increment will always be greater than the overall return, but the instantaneous return on each successive increment will be less than that on the preceding increment until a point is reached at which the instantaneous return at that thickness is exactly equal to the overall return. Beyond this point, the instantaneous return will always be less than the overall return. Therefore, the instantaneous return on the *final* increment is always less than the overall return, and the relationship between the two is variable, as previously indicated.

The correspondent stated that "it must be emphasized that in fixing an overall return on the insulation investment, lower returns may result on the latter increments of thickness than may be economically justified." While this is theoretically true, its practical significance is debatable. It should be equally emphasized that if the overall return is considered satisfac-

[10] A. S. M. E. Transactions, Vol. 48, 1926, page 1269.
[11] A. S. M. E. Transactions, Vol. 48, 1926, page 1301.
[12] Refrigerating Engineering, Nov. 1922, page 152.
[13] Heating and Ventilating, March, 1931, page 65.
[14] Heating and Ventilating, April, 1931, page 94.

tory, the installation of the full thickness involved can be justified, even though the return on the "latter increments of thickness may not be economically justified." Either the overall return or the instantaneous return on the final increment of thickness may be used as the limiting factor in determining the thickness, if the proper values are used. Nevertheless, the purchaser buys the full thickness of insulation, and the last few increments may have little importance when compared with the overall thickness.

The following statement was made by the correspondent: "The proper method for determining the correct thickness of insulation is that which requires the return on the last increment of thickness to be the minimum return acceptable." For the optimum thickness, the return on the final increment of thickness may vary considerably for various conditions. Likewise, the overall return will vary. If it is assumed that the return on the final increment of thickness for the optimum thickness is the "minimum acceptable return" for that thickness, then the "minimum acceptable return" on the final increment, as well as the "minimum acceptable return" on the overall thickness will vary considerably. From this standpoint, the formula to which the correspondent subscribes is as much in error as the one to which he does not subscribe. In determining the so-called optimum thickness, the return on the investment (whether overall or instantaneous) is not necessarily considered. Even if the limiting factor is some preselected value of the return on the investment, it does not necessarily mean that the thickness thus obtained is the optimum or most economical thickness. But it should be reiterated that the formulae presented by the writer were not intended to give the optimum thickness, but rather the thickness which will result in a certain minimum acceptable return on the investment.

It matters little what the subject may be, there are always differences of opinion concerning it. Even those who agree generally on the fundamental principles of the subject may differ on certain details of it. The economics of insulation seem to be no exception to the rule. Only those who venture to express their opinions are likely to be criticized, and whether the criticisms be justified or not, this is one of the evils of such endeavors. It should be remembered, however, that pitfalls are likely to be encountered when one endeavors to discuss two propositions, neither of which one has originated.

Part II—Insulation for Gas Heated Buildings

SYMBOLS USED IN THIS ARTICLE

c=cost of coal—dollars per ton.

C_c=calorific value of coal—B.t.u. per pound.

C_g=calorific value of gas—B.t.u. per cubic foot.

E_c=overall heating efficiency for coal—per cent (expressed as a decimal).

E_g=overall heating efficiency for gas—per cent (expressed as a decimal).

F_c=fuel saving in tons of coal per heating season per one square foot of wall or roof area.

g=average cost of gas fuel—dollars per 1000 cu. ft.

I_r=instantaneous return on investment for final increment of thickness—per cent.

k=conductivity of insulation in B.t.u. per hour per square foot per degree Fahrenheit.

N=number of hours during heating season.

p=cost of oil—cents per gallon.

r=overall return on investment—per cent.

s=monetary value of saving of steam radiation—dollars per equivalent square foot.

t=average inside temperature near wall or roof—degrees Fahrenheit.

t_a=average outside temperature during heating season—degrees Fahrenheit.

t_o=outside temperature on which design of heating system is based—degrees Fahrenheit.

U=Coefficient of transmission of uninsulated wall or roof—B.t.u. per hour per square foot per degree difference in temperature.

U_i=coefficient of transmission of insulated wall or roof—B.t.u. per hour per square foot per degree difference in temperature.

Y_g=thickness of insulation for gas fuel—inches.

Y_m=thickness of insulation for manufactured gas—inches.

Y_{ms}=thickness of insulation for manufactured gas and direct radiation steam heating system—inches.

z=installed cost of insulation—cents per square foot per inch thickness.

Z_i=cost of insulated wall or roof per square foot—cents.

Z_u=cost of uninsulated wall per square foot—cents.

$Z_i - Z_u$=difference between the cost of the insulated and uninsulated wall or roof, in cents per square foot (this in many cases will be the same as the installed cost of the insulation for the thickness involved).

OTHER things being equal, the more costly the fuel used, the greater the thickness of insulation required for buildings. Where manufactured gas is used for heating purposes, it usually is more expensive than other fuels.

For example, if the average cost of manufactured gas is $0.75 per thousand cu. ft. (including both demand and commodity charges) the cost per million B.t.u. will be about $1.75, based on a calorific value of 535 B.t.u. per cu. ft. and an efficiency of 80%. Oil at 10 cents per gal. would cost about $1.00 per million B.t.u. based on a calorific value of 141,000 B.t.u. per gal., and an efficiency of 70%, whereas coal at $10.00 per ton would cost $0.64 per million B.t.u., for a calorific value of 13,000 B.t.u. per lb. and an efficiency of 60%. Although actual fuel costs, of course, vary in different localities, these figures give some idea of relative heating costs with these three fuels. It should be borne in mind, however, there are other factors to be considered than merely the costs per million B.t.u.

Theoretically, the heating costs with different fuels can be equalized by effecting a reduction in the heat losses of the building corresponding to the cost of the fuel. Because of practical limitations and also because of the difference in cost of fuel burning devices, this hypothesis is only partly true. Furthermore, the "expense" of reducing the heat losses is a factor to be considered, even though offset to some extent by the reduction in the amount or size of heating equipment required.

By ascertaining the required reduction in heat losses in order to utilize an expensive fuel at little or no greater cost than a cheap fuel, the extent to which the various heat-reducing factors (i.e., insulation, weatherstripping, and multiple windows) should be applied could be readily determined, disregarding equipment costs. This could therefore be used as the basis for estimating the thickness of insulation to use. But this procedure is more or less involved and probably would be of little value from a practical point of view.

Insulation Thickness Based on Return on Investment and Fuel Saving

A more simple basis is that of the return on the investment. The general equation for estimating the thickness of insulation for gas-heated buildings when based on the overall return on the investment is as follows:

$$Y_g = \frac{10 \times g \times U \times N \times (t-t_a)}{r \times z \times C_g \times E_g} - \frac{k}{U} \qquad (28)$$

The derivation of this equation is similar to that for coal and oil given in previous articles. The principle upon which the derivation is based has been stated.[15] It is believed that this principle is so obvious as to be axiomatic and therefore fully substantiates the validity of the formulae quoted, notwithstanding the fact that there are other premises upon which the insulation thickness may be determined.

[15] HEATING AND VENTILATING, August, 1930, page 71.

If, in equation (28), N=5040, C_g=535 (for manufactured gas), and E_g=0.80 then—

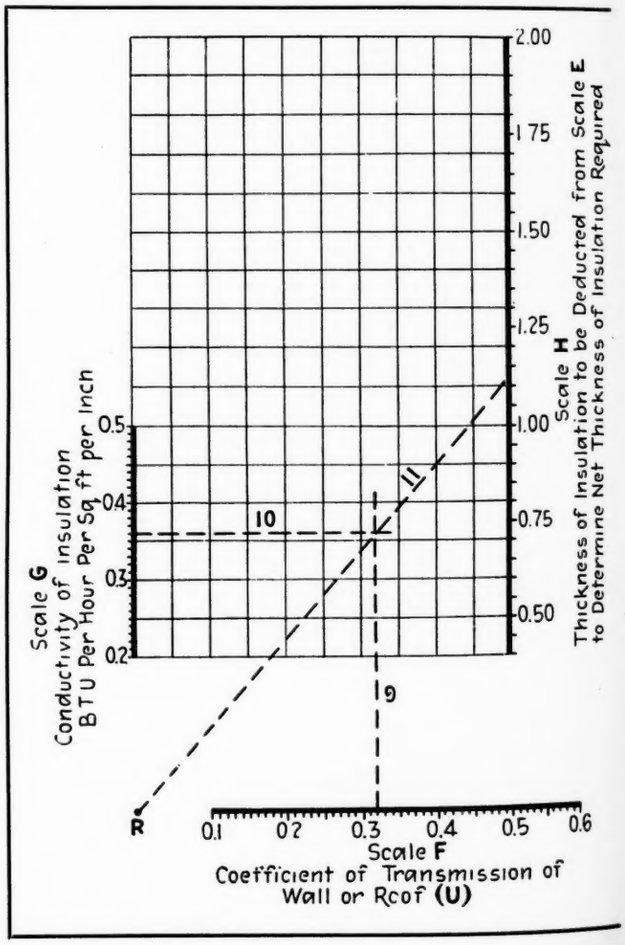
$$Y_m = \frac{118 \times g \times U \times (t-t_a)}{r \times z} - \frac{k}{U} \qquad \text{(Formula J)}$$

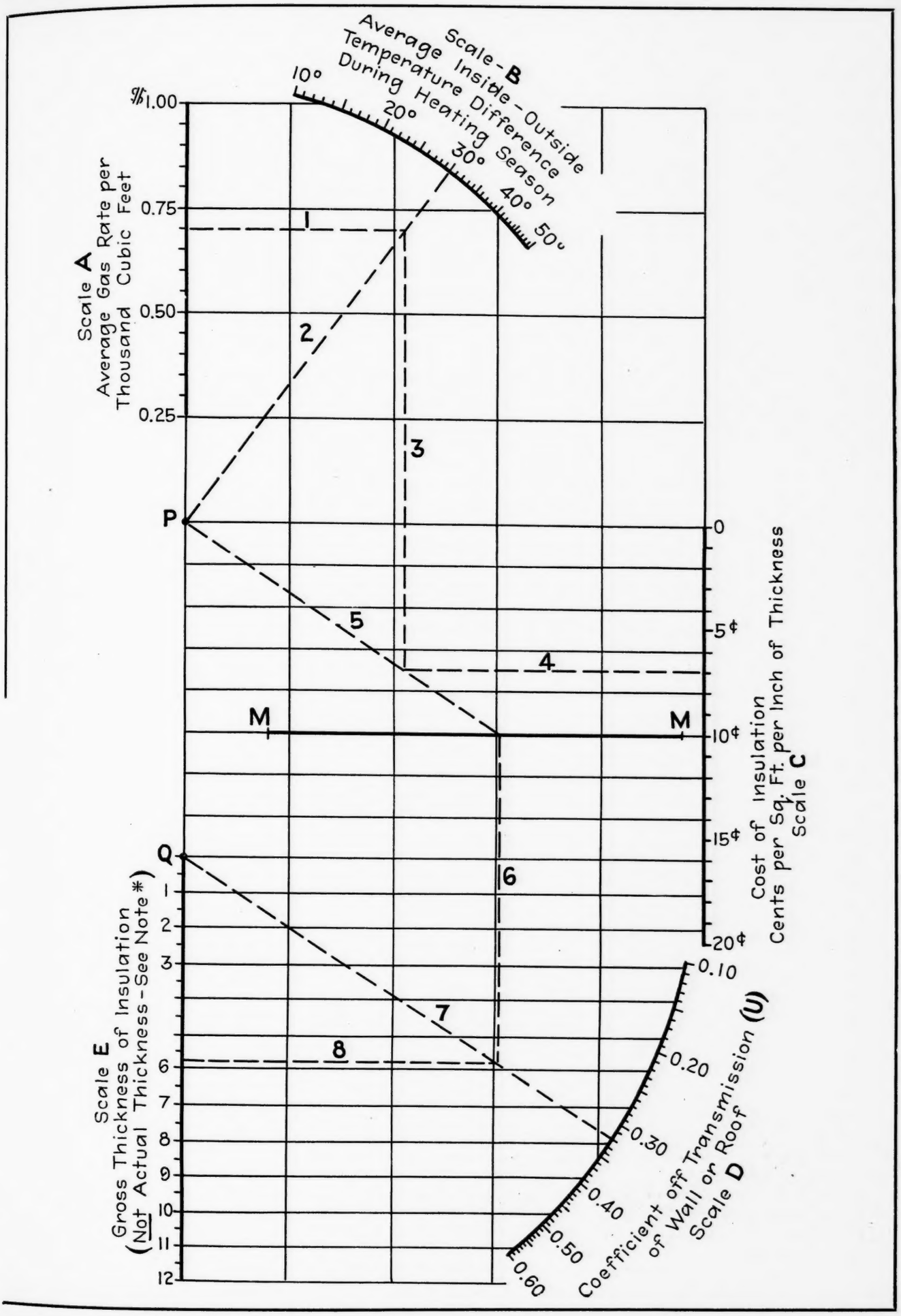
A typical problem will serve to illustrate this formula. The average cost of manufactured gas (g) for a certain residence is $0.75 per thousand cu. ft. The coefficient of transmission (U) of the uninsulated wall is 0.30, and the average temperature difference during the heating season ($t-t_a$) is 34°. If the insulation costs 12 cents per sq. ft. per in. thickness, installed (z), and the conductivity of the insulation (k) is 0.35, the thickness of insulation for an overall return on the investment (r) of 20%, will be—

$$Y_m = \frac{118 \times 0.75 \times 0.30 \times 34}{20 \times 12} - \frac{0.35}{0.30} = 2.6 \text{ in.}$$

The accompanying chart, which may also be used for estimating the thickness of insulation to use for manufactured gas-fired residences, is based on formula J, and an overall return on the investment of 20%. A problem

Fig. 9. Charts for Estimating Thickness of Insulation for Gas Heated Buildings. The Actual Thickness of Insulation Is Obtained by Subtracting the Thickness Obtained from Scale H, from the Thickness Obtained from Scale E. Dotted Line Indicates Solution of Typical Problem. Draw Lines in the Order Indicated by Numbers.




Scale B
Average Inside-Outside
Temperature Difference
During Heating Season
10°
20°
30°
40°
50°
Scale A
Average Gas Rate per
Thousand Cubic Feet
1.00
0.75
0.50
0.25
1
2
3
P
5
4
M
M
6
Q
7
8
Scale C
Cost of Insulation
Cents per Sq. Ft. per Inch of Thickness
0
5¢
10¢
15¢
20¢
Scale D
Coefficient of Transmission (U)
of Wall or Roof
0.10
0.20
0.30
0.40
0.50
0.60
Scale E
Gross Thickness of Insulation
(Not Actual Thickness - See Note *)
1
2
3
6
7
8
9
10
11
12

may be solved by drawing lines in the order indicated by the numbers adjoining the dotted lines.

The insulation thickness for manufactured gas may also be determined by means of the following formula, in which the instantaneous return on the final increment of thickness is the limiting factor:

$$Y_m = \frac{118 \times k \times g \times (t-t_a)}{z \times I_r} - \frac{k}{U} \qquad \text{(Formula K)}$$

By solving formulae J and K, the relation between the instantaneous return on the final increment of thickness and the overall return, will be found to be—

$$I_r = \frac{r^2 \times k \times z}{118 \times g \times (t-t_a) \times U^2} \qquad \text{(Formula L)}$$

In the problem previously cited, the instantaneous return at the final increment, for an overall return of 20%, and for the other conditions involved, will be—

$$I_r = \frac{(20)^2 \times 0.35 \times 12}{118 \times 0.75 \times 34 \times (0.30)^2} = 6.1\%$$

For natural gas, if the calorific value is 1000 B.t.u. per cu. ft. instead of 535, the constant in formulae J, K and L will be 63 instead of 118.

Thickness for Both Fuel and Radiation

Thus far in this article the thickness of insulation has been considered solely from the standpoint of the fuel saving. As explained in previous articles, if the radiation saving is also considered, the thickness will be somewhat greater than if the fuel saving only is involved. This is because the monetary value of the radiation saving is deductable from the cost of the insulation, making the net cost for any specified thickness less than when radiation is not considered. Since the net cost is less, the return due to the fuel saving will be greater, and therefore an additional thickness of insulation will be required to obtain the same percentage return on the investment as when the fuel saving only is considered.

The thickness of insulation for manufactured gas and a steam heating system may be estimated by means of the following formula:

$$Y_{ms} = \frac{118 \times g \times (t-t_a) \times U + 0.417 \times (t-t_o) \times r \times s \times U}{r \times z} - \frac{k}{U} \qquad \text{(Formula M)}$$

The derivation of this formula is, of course, similar to that for other combinations of fuel and radiation given in previous articles.

If, in the problem previously cited, the monetary value of the saving in radiation for a steam heating system (S) is $0.60 per sq. ft., and if the temperature difference upon which the design of the heating system is based $(t-t_o)$ is 70°, the thickness of insulation required for these conditions, according to formula M, would be:

$$Y_{ms} = \frac{118 \times 0.75 \times 34 \times 0.30 + 0.417 \times 70 \times 20 \times 0.60 \times 0.30}{20 \times 12} - \frac{0.35}{0.30}$$

$$= 3.0 \text{ in.} +$$

Thus the radiation saving when considered with the fuel saving would increase the thickness of insulation about 0.4 in. for the specific conditions involved, and for this method of arriving at the insulation thickness.

The formula for natural gas and a steam heating system would be similar to that for manufactured gas, excepting that instead of the factor 118 for manufactured gas, the constant would be 63 for natural gas if the calorific value of the gas is 1000 B.t.u. per cu. ft., provided the other assumptions are the same.

For a hot water system and either manufactured gas or natural gas, the constant would be 0.625 instead of 0.417, as in formula M. The constant of 0.625 is determined on the basis of a heat emission of 160 B.t.u. per hr. per sq. ft. of equivalent direct radiation.

It is interesting to note that there is a similarity between formula M for fuel and radiation and formula J for fuel only. The quantity $[118 \times g \times (t-t_a) \times U]$ appears in both equations and hence, the quantity which appears in formula M, but not in formula J, namely $[0.417 \times (t-t_o) \times r \times s \times U]$ reflects the influence of the saving in radiation.

Part III—Special Conditions

UNDER certain conditions, the results obtained by means of the formulae thus far presented would not be wholly consistent because of changes in the heat resistance due to the manner of installation of the insulation. There are three such special conditions, as follows:

1. Insulation used in place of other materials in the construction, as for example, sheathing and plaster base.

2. Insulations installed in a manner such that the number of air spaces is increased.

3. Insulation installed in a manner such that the number of air spaces is decreased.

If the manner of application of the insulation involves any of these conditions, as is usually the case, the insulation thickness may be obtained by using the formulae thus far presented either by neglecting these

factors, or by making allowance for them in the variables affected. Still another method would be to assume the desired minimum return on the investment, and to determine the thickness by trial and error, by means of the following formulae:

$$r = \frac{3.23 \times (U-U_i) \times c \times (t-t_a)}{(Z_i-Z_u)} \quad \text{(Formula N — for coal)}$$

$$r = \frac{5.11 \times (U-U_i) \times p \times (t-t_a)}{(Z_i-Z_u)} \quad \text{(Formula O — for oil)}$$

$$r = \frac{118 \times (U-U_i) \times g \times (t-t_a)}{(Z_i-Z_u)} \quad \text{(Formula P — for manufactured gas)}$$

Formula N is derived as follows:

The return on the insulation investment (r) is obtained by dividing the monetary value of the fuel saving by the extra cost of the insulation. The former is equal to ($F_e \times c$) and the latter is equal to

$$\frac{Z_i-Z_u}{100}$$

To change to per cent, multiply by 100, therefore—

$$r = \frac{100 \times F_e \times c}{\frac{(Z_i-Z_u)}{100}} = \frac{10{,}000 \times F_e \times c}{(Z_i-Z_u)} \quad (29)$$

Substituting the value of (F_e) obtained from equation (1)[16] in equation (29)—

$$r = \frac{5 \times (U-U_i) \times N \times (t-t_a) \times c}{C_e \times E_e \times (Z_i-Z_u)} \quad (30)$$

As in formula A, let $N = 5040$, $C_e = 13{,}000$ and $E_e = 0.60$. Then—

$$r = \frac{3.23 \times (U-U_i) \times c \times (t-t_a)}{(Z_i-Z_u)} \quad \text{(Formula N)}$$

Formulae O and P are derived in a similar manner.

1. Insulation Used in Place of Other Materials

Board or rigid type insulations are frequently used in place of other materials, particularly for sheathing and plaster base. The recommended procedure for determining the thickness of insulation under the circumstances is to ascertain the return on the investment (r) for the minimum commercial thickness from formulae N, O or P, depending on the type of fuel used. The return would be based on the application of this minimum thickness for either sheathing or plaster base. If the value of r is more than the minimum acceptable value, a greater thickness may be warranted.

This procedure should be continued, using the next commercial thickness of the insulation under consideration. For the rigid type insulation, this thickness would, in the case of frame walls, consist of one layer used for sheathing and one layer for plaster base. If the return on the investment is still too high, the process should be continued, adding successive thicknesses of the product under consideration until the value of r is approximately 20%, or whatever the minimum acceptable value may be.

The following problem will illustrate this procedure: Determine the thickness of the rigid type of insulation to use in a brick veneer frame wall as sheathing or plaster base or both, if oil is the fuel used. The inside temperature is 70°, the average outside temperature during the heating season is 40°, and the cost of oil is 8.2 cents per gal.

The first trial is made on the basis of two ½ in. thicknesses of the insulation under consideration, one used as sheathing and the other as plaster base. The cost of the insulated wall in this case is 3.9 cents per sq. ft. more than the uninsulated wall, and therefore $Z_i-Z_u = 3.9$; $U=0.247$; $U_i=0.166$. Since the building is heated with oil, formula O would be used. Substituting the foregoing values in this formula—

$$r = \frac{5.11 \times (0.247 - 0.166) \times 8.2 \times 30}{3.9} = 28.7\%$$

Since the return for this thickness exceeds the desired return of 20%, the process will be repeated using the next commercial thickness of this material, which is 1½ in., ½ in. being applied as a plaster base and 1 in. as sheathing, for which the "U" value of the wall is 0.133. The insulated wall is assumed to cost 7.9 cents per sq. ft. more than the uninsulated wall in this case, or $Z_i-Z_u=7.9$. Therefore—

$$r = \frac{5.11 \times (0.247-0.133) \times 8.2 \times 30}{7.9} = 18.1\%$$

The thickness in this case is 1½ in. when installed as stated for the conditions involved, since the return for this thickness is nearest to 20%, the desired return.

It should be understood that the rigid or board forms of insulation may not always be installed in a manner such that they are used in place of other materials, and the problem would therefore not be a special case. For example, the rigid type insulation is sometimes installed against the sheathing under the interior finish, in which case the thickness would be determined directly by means of formula A or B for coal, E or F for oil, etc. When used as roof insulation between the roof deck and roofing, these formulae apply without modifica-

[16] Heating and Ventilating, August, 1920, page 71.

tions. For most other cases, it is recommended that formula N, O or P be used.

2. Insulations Installed So that an Additional Air Space Is Created

Flexible or semi-rigid insulations are frequently installed between joists, studding or rafters so that they add one or more air spaces to the wall or roof. The thickness may also be determined in this case by trial and error, starting with the minimum commercial thickness and increasing the thickness until the desired minimum return on the investment, e.g. 20%, is obtained approximately. The rigid type of insulation may also be installed between the studding so that an air space is added.

3. Insulation Installed So That Air Space Is Filled

Fills frequently may be installed in only one thickness which is the width of the air space between the studding or furring strips. The thickness can be readily varied in the case of masonry walls by changing the width of the furring strips but in the case of frame walls, the thickness usually is either 3⅝ in. or 5⅝ in., the widths of 4 in. and 6 in. studding, respectively. Of course, the width of the space between the studding occupied by a fill can be varied by installing thin partitions, but this construction is seldom used, because the saving obtained by so doing would be offset in most cases by the added cost of the construction. If, however, this method is adopted, the number of air spaces in the construction is not changed and the thickness required may be calculated by means of formula A or B for coal, E or F for oil, etc.

If a fill is installed between the studding so as to occupy the entire space there is no choice in the matter of thickness, and the problem then resolves itself into a question of whether or not the insulation pays, when considered from the economic standpoint. In other words, one of two conditions will exist, the insulation pays a satisfactory return or it does not, and its use would be governed by this situation. If the overall return for the type of fuel involved, is considerably less than 20% (or whatever the minimum acceptable value may be) there would be some doubt as to whether this particular insulation should be used for the conditions involved. For example, if fuel were exceptionally low in cost in a certain locality, and the type of insulation considered would only result in an estimated return of 3 or 4% on the money expended for it, it is apparent that the use of this insulation—or perhaps any other type—would not be justified.

Fill Installed Between Studding Can Be Considered Only From Standpoint of Overall Return on Investment.

The other extreme is also possible with a fill, namely, that the high cost of fuel would justify the installation of a thickness of insulation greater than can be obtained by placing the material between the studding. In the case of new buildings, the additional insulation might be installed as sheathing or plaster base, by using the rigid type. The overall return on the investment for a fill of any type or thickness, in combination with any other type, may be calculated by means of formula N, O or P. Obviously, a fill installed between studding can only be considered from the standpoint of the overall return on the investment.

If a fill is installed between the ceiling joists, the thickness can readily be varied. If an air space is not filled, then any of the first formulae (i.e. A, B, E, F, etc.) may be used, but if the space between the plaster base and flooring above is filled, then it is usually advisable to apply one of the formulae for r (N, O or P), the thickness being governed by the return on the investment.

Formula N is similar to formula A except that the former takes into consideration the difference in the costs of the insulated and uninsulated constructions, which may not be the same as the installed cost of the insulation alone, for the reasons already stated. Furthermore, formula N involves the coefficient of transmission of the insulated construction and therefore allows for the replacement of other materials by the insulation or any change in the number of air spaces due to the installation thereof. This, of course, applies also to the formulae for the other heating media.

Summary and Conclusions

In this series of articles, the thickness of insulation has been based on the return on the investment. It was explained that although the usual tendency is to secure the highest return on the investment, this practice cannot be followed in selecting insulation, because the higher the return on the insulation investment, the greater the cost of heat. The minimum thickness will ordinarily result in the maximum return on the investment. Consequently, the aim is to select the thickness of insulation which will reduce the heat loss to the greatest extent and at the same time pay a satisfactory return on the investment. An overall return of 20% was chosen as the minimum acceptable value in the problems cited, although the thickness determined on this basis may not necessarily be the most economical thickness.

The most economical thickness should probably be considered as that thickness at which the sum of the annual insulation and heat costs is a minimum. In any event, the problem involves many factors of a somewhat indefinite nature, and it is therefore illogical to extend the calculations beyond the degree of refinement involved. While the methods given by the writer may or may not be the most accurate, they are believed to be consistent with the general accuracy involved, and are at least far better than the quite prevalent practice of blindly selecting an insulation without any regard for the return on the investment. It should be emphasized that there may be other bases than the economic by which the selection of insulation may be governed, such as the prevention of condensation and the less tangible "summer comfort" idea.

Fig. 1. Interior of an Air Conditioned Candy Plant.

Air Conditioning

By WILLIAM HULL STANGLE

X-Body Heat Losses and Comfort Charts

By REALTO E. CHERNE†

THE ability of determine heat content, moisture content, and other physical and chemical properties of the air is only a beginning in applying the data in air conditioning to human comfort. Before much headway in practical application can be made, it is necessary to know: first, the conditions at which humans actually experience the sensation of comfort in their air surroundings, and second, the amount of heat given off by them in such circumstances. The latter may be absorbed and taken away by the circulating air stream.

We are all more or less familiar with the process of metabolism by which the body utilizes the heat content of food, converting some into mechanical energy and transferring the remainder into the blood from which the waste heat, water vapor and other by-products are dissipated through the skin and lungs. Fortunately, nature has given to the body some power to regulate, within limitations, the rate of this heat dissipation. In addition, man has adapted to his use clothing of various weights to use during the changing seasons. In air conditioning for human comfort, therefore, the principal effort should be directed to the removal of waste heat from the body by means of radiation, conduction and evaporation.

Recently, some studies have been made on the subject when circulating air is the agent for picking up the heat dissipated from the body, and on the nature and amount of the heat so given up. As a result interesting data, sufficiently accurate for use, are available. It has been found that between about 65° and 85° effective temperature (defined later in this article) the total amount of heat lost from a human body (average man of about 19.5 sq. ft. of surface) slightly active, normally clothed, is approximately 400 B.t.u. per hr. For lower effective temperatures the amount of heat lost increases gradually to approach 525 B.t.u. per hr. at 45°; likewise for higher effective temperatures the amount of heat produced tends to increase.

That portion of the total heat given off by radiation and conduction is termed sensible heat while that given off by evaporation is termed latent heat. The percentage of sensible heat varies with the dry bulb temperature and approaches 88% at 45°, 55% at 80° and 0% at 102°. It is evident that the percentage of latent heat, that is, the heat given off in the form of evaporated moisture, is the complement of the sensible heat percentage since the two at all times must add up to 100%. More detailed analysis of such data would show that at 80° dry bulb (the temperature ordinarily considered as a basis of comfort conditioning under maximum summer weather conditions) 220 of the 400 B.t.u. per hr. given off by the human body would be sensible and the remainder—180 B.t.u.—would be latent. Interesting problems in connection with the above data may be solved by the use of proper charts and curves.

†Carrier Engineering Corporation.

Since these charts and curves are rather numerous they are not here reproduced. Ordinary comfort conditioning problems may be solved with sufficient accuracy by the use of the values stated above.

To one not conversant with the intricacies of the science of air conditioning, it may seem to be drawing a rather fine line to differentiate between the two forms of heat just explained. But such is not the case —for, in general, the total amount of sensible heat determines the amount of conditioned air to be used in a room, while the latent heat is a measure of the amount of moisture change necessary to maintain the desired condition of humidity. In the case of summer operation the latent heat may be a measure of the amount of refrigeration.

It has been roughly known for some time that the sensation of comfort in air is dependent upon the body losing its heat effectively. Moreover, it has been known that the temperature and moisture content, as well as the air movement, have marked effects on this feeling of comfort. What was lacking was a numerical scale on which to base practical calculations. Some eight or ten years ago studies were undertaken to provide such data in convenient form. The studies consisted of subjecting a considerable number of persons to various controlled air and moisture mixtures. The individuals indicated their feeling of comfort or discomfort. The data resulting were correlated and plotted superimposed on a psychrometric chart in such a manner that conditions of equal comfort were joined by lines on the chart. These lines of equal comfort are shown on the chart Fig. 2 which gives that portion of the studies applicable to still air conditions.

One of the interesting things about this chart, and the studies on which it was based, is that these lines of equal comfort were assigned the name of equal effective temperature lines. *Effective temperature* may be defined as an experimentally determined scale made up as a composite of dry bulb temperature, humidity, and air motion which gives a true index of a person's feeling of warmth. Different combinations of the above three factors may give the same effective temperature or degree of comfort. This fact is substantiated by the general experience of heating engineers in observing that the lower the humidity the higher the dry bulb temperature required for the same degree of comfort.

The comfort chart is made up in such a manner that all such combinations which give the same degree of comfort fall on the same line. As was stated before, at low dry bulb temperatures the major portion of the body heat is removed by radiation and convection while at high temperatures the greater portion is removed by evaporation. Thus, the effective temperature lines approximate the wet bulb lines at comparatively high temperatures and the dry bulb lines at comparatively low temperatures.

This effective temperature scale and the lines on the chart (Fig. 2) make possible the solution of some very interesting problems, of which several examples are given:

For instance, assume that we wish to know the effective temperature if the dry bulb temperature is 72° and the wet bulb temperature is 58°. Locate the intersection of the 58° wet bulb line, which runs downward to the right at an angle of about 30° to the horizontal, and the vertical 72° dry bulb line. We find that

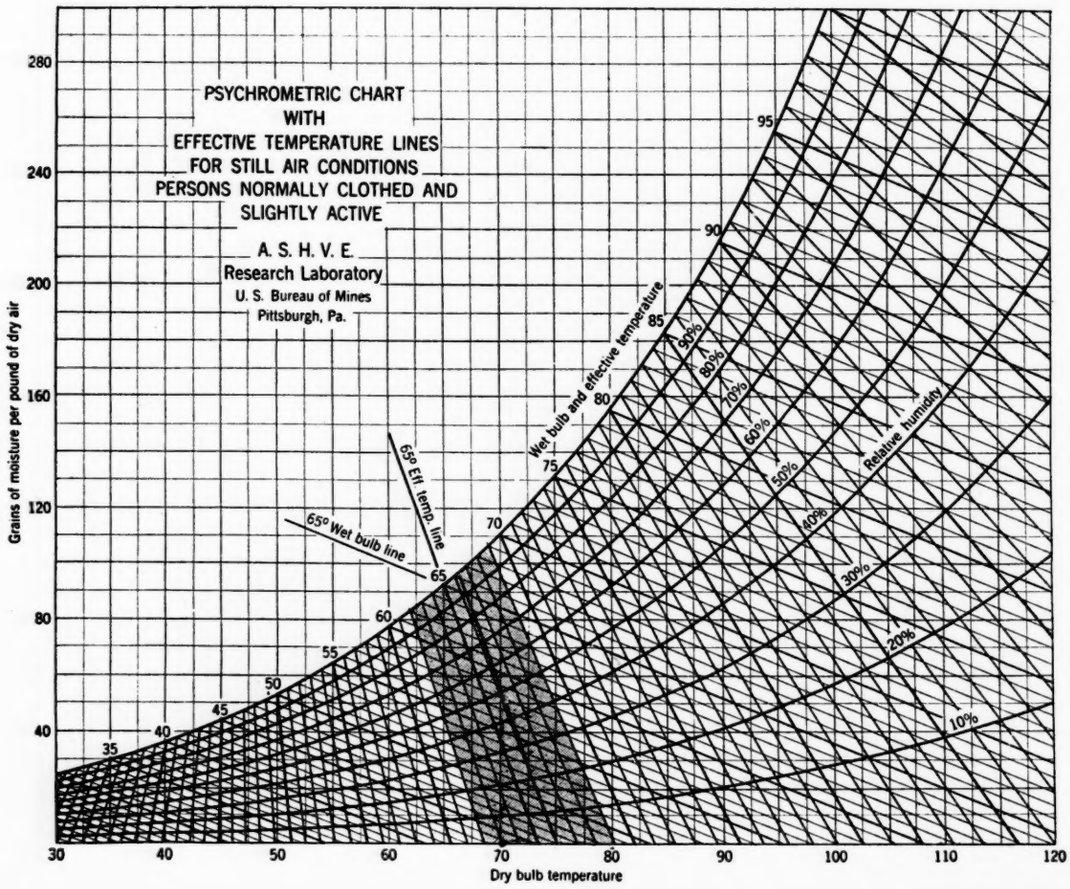


Fig. 2. Comfort Chart for Still Air Conditions.
A. S. H. V. E. Guide

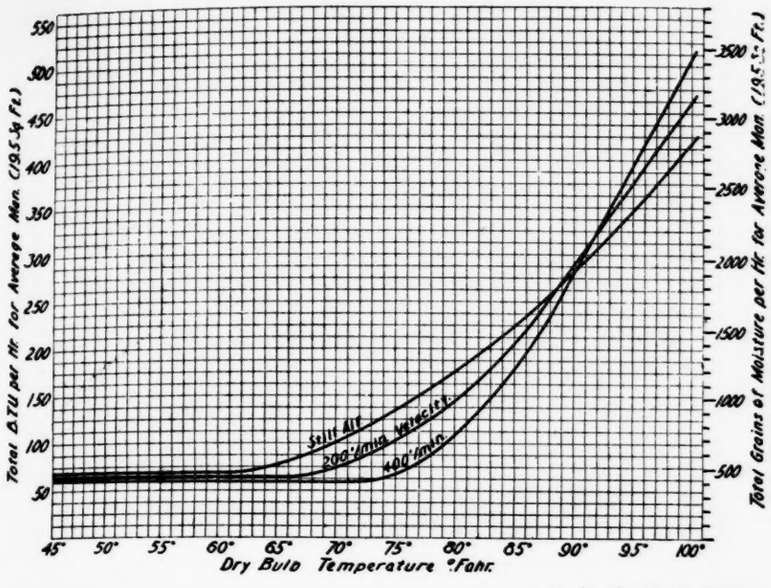

Total BTU per Hr. for Average Man (19.5 sq. Ft.)
Total Grains of Moisture per Hr. for Average Man (19.5 sq. Ft.)
Still Air
200 f/min Velocity
400 f/min
Dry Bulb Temperature °Fahr.
A. S. H. V. E. Trans.

Fig. 3. Relation between heat and weight loss from the human body by evaporation and dry bulb temperatures for still and moving air.

the effective temperature on the lines running downward to the right at an angle of about 80° with the horizontal, to be 67° effective temperature, 3° warmer than the comfort line.

Suppose that we wish to determine whether a condition with a dry bulb of 68° and a wet bulb of 60° feels warmer or cooler than a condition with a dry bulb of 76° and a wet bulb of 62°. In the same manner as the previous problem was solved, we find the intersection of the 68° dry bulb and 60° wet bulb lines to give an effective temperature of 65.2°. The intersection of the 76° dry bulb and 62° wet bulb give an effective temperature of 70.2°. The second condition, therefore, is 5° effective temperature warmer than the first.

In this last example, assume that we wished to make the second condition the same in comfort as that of the first. What change in moisture content must take place? Locate the effective temperature for the given dry and wet bulb temperatures and read horizontally to the left, where we find a moisture content of 64 grains of moisture per pound of dry air for the first condition. Reading on the moisture scale to the left of the intersection of the 76° dry bulb and 62° wet bulb, we find a moisture content of 61 grains of moisture per pound of dry air for the second condition. Consequently, to make the second condition equal to the first we must add 3 grains of moisture to each pound of dry air.

Air motion has an effect on human comfort, as is evidenced by the data plotted on the chart, Fig. 5. This chart is also the result of experiment.

Suppose we wish to know how much cooler a condition with 75° dry bulb temperature, 65° wet bulb temperature, with 300 ft. per min. velocity of the air would be than the same temperature conditions in still air, so far as effective temperature is concerned. On Fig. 2 it will be found that this condition in still air for persons normally clothed and slightly active is 70.8° effective temperature. Referring to Fig. 5, if the air has a velocity of 300 ft. per min. it will be found that the effective temperature is 66.3° The cooling effect is consequently 70.8°—66.3°, or 4.5°.

Studies made a few years ago showed that standards of comfort so far as the temperature, humidity and air ~~comfort~~ motion are concerned are not absolute, and are considerably affected by climatic and other conditions. This variation appears to be caused by differences in clothing worn in different climates and at different times of the year, as well as by the psychological changes which take place in man in response to climatic changes.

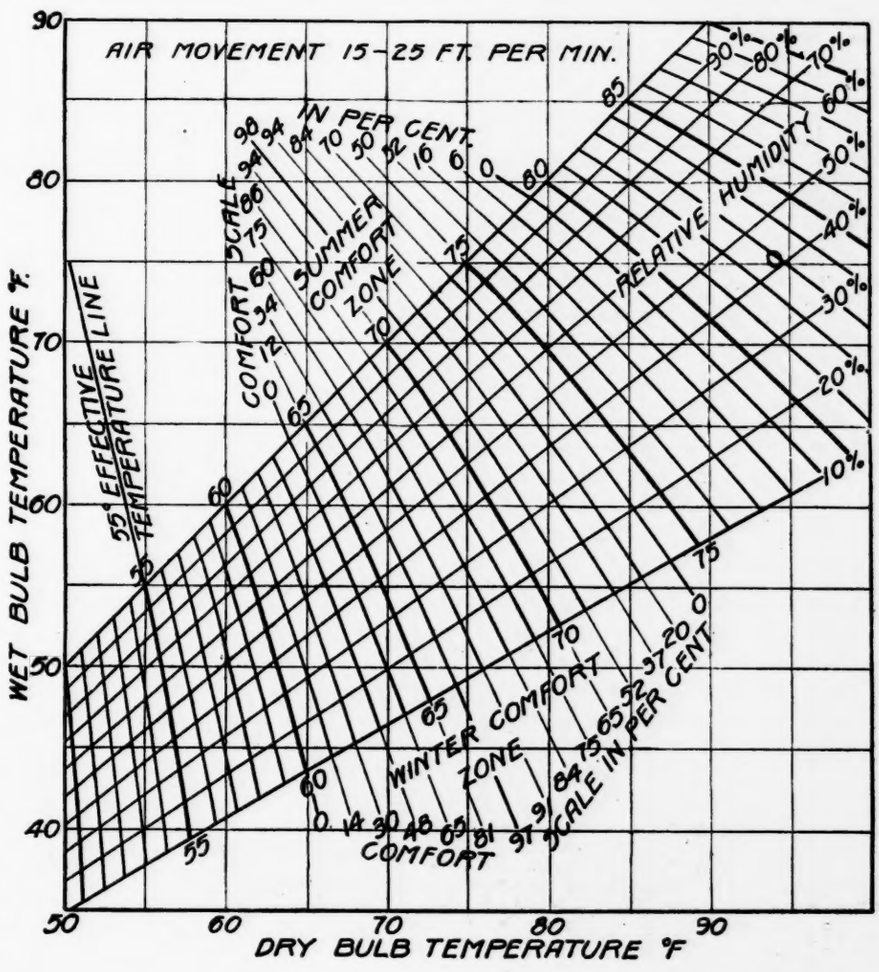


Fig. 4. Effective temperature chart showing summer and winter comfort zones.

Work done by Yaglou and Drinker carried on with subjects ranging in number from 8 to 25 showed that the summer comfort for men and women wearing customary warm weather clothing in the United States, lies between 64° and 79° on the effective temperature scale, with the probable most comfortable temperature being at 70.5° effective temperature. On the average these values are about 4.5° effective temperature higher than those found in winter. The difference is said to be due to the adaptation to the weather as well as to seasonal variation in the clothing worn.

Summer and Winter Comfort Zone Data Not Applicable to All Conditions

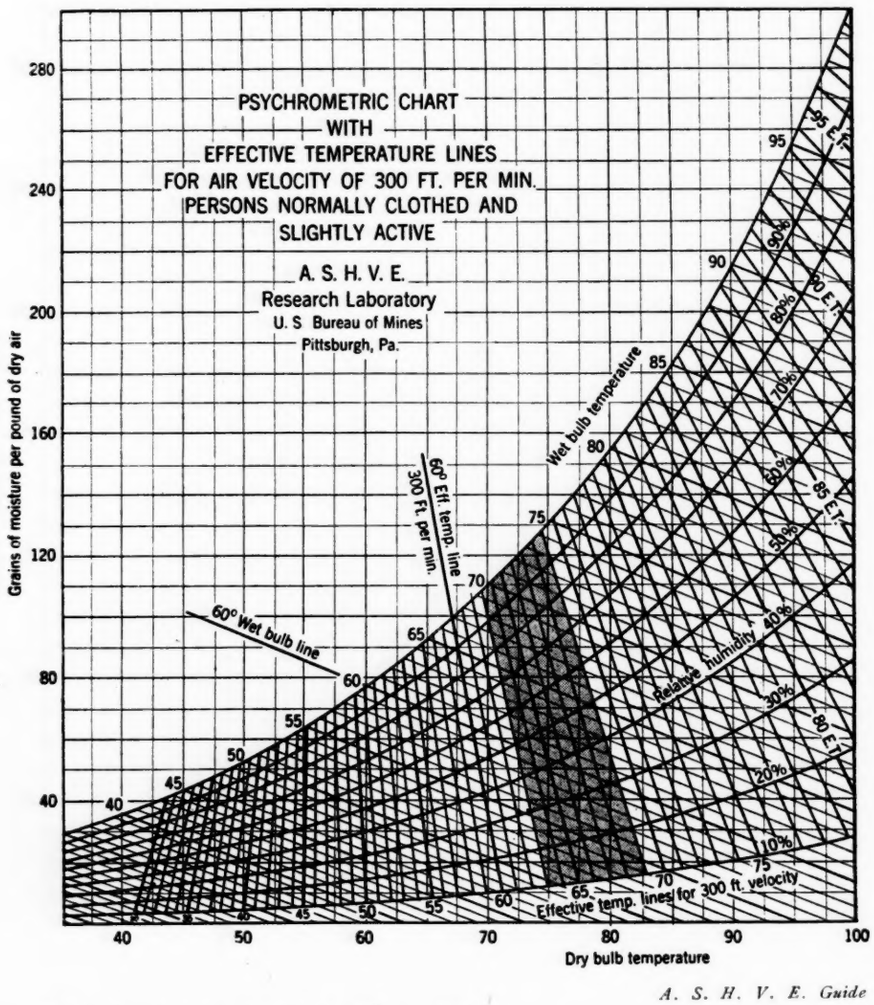
Data from these tests were plotted on the chart shown in Fig. 4, from which we can see that a dry bulb temperature of 70° with relative humidity of 40% gives us a 97% comfortable effective temperature in winter, while in summer these conditions would give us only a 34% feeling of comfort, or in other words, in the summer a temperature of 70° and a relative humidity of 40% would feel distinctly chilly, although we would feel completely comfortable in the winter. These data are based on an air movement of from 15 to 25 ft. per min.

In connection with the use of these data it should be noted that they do not represent absolute measurement but that they are applicable to the conditions under which they were determined.

It should also be understood that these several charts represent data obtained under certain set conditions and may not apply to others. They are especially valuable for use in estimating design quantities but are not necessarily suitable for use on the basis of operating schedules. They do, however, represent the best knowledge now available on the subject and it is felt that they may be used for design calculations.

To summarize, available data are in such shape that, knowing the conditions of the outside and inside air, the occupancy of the space to be conditioned, the load on the conditioning equipment can be determined. The data, as pointed out, are applicable to comfort conditions only. However, inasmuch as these articles are primarily concerned with comfort conditions, comparatively little attention will be paid to industrial air conditioning.

It is worth noting, in passing, that air conditioning for comfort is comparatively new. Formerly, the chief field for air conditioning was in industrial establishments because its benefit in uniformity and continuity of production were more readily evaluated in dollars and cents. More and more the employers are beginning to realize that air conditioning for human comfort pays handsome dividends in increased personal efficiency, improved health and enjoyment of life, and lessened labor turnover. In many industrial applications where proper conditions are necessary for the production of a uniform efficiency, it has been found that the increased personal efficiency has been more than enough to pay the overall operating and owning costs of the conditioning plant—to say nothing of the material gain due to a better product.



A. S. H. V. E. Guide

Fig. 5. Psychrometric chart with comfort lines superimposed, for 300 ft. velocities.

Although industrial air conditioning is older in application than conditioning for comfort complete data are not available. The reason for this is that in air conditioning for the furtherance or improvement of a manufacturing product the end conditions to be met are different for almost all of the materials undergoing the process. A wide range of industrial plants have been air conditioned—tobacco, candy, paper, silk, clay, etc.—so that it is easy to understand that the collection of data even for a single industry is not a simple matter, especially when it is known that one particular factory, such as a candy plant, may have numerous different conditions to meet in different departments. Hard candy may require certain conditions, milk chocolate another, and so on.

Future installments will consider the matter of air conditioning equipment.

Abstracts . . .

Reviews and Summaries of . . . Current Papers, Books and Pamphlets

Cooling Theaters With Ice

By E. W. Schadek

Ice and Refrigeration, Chicago, pages 377 to 379, May, 1931. About 2000 words, sketches and tables.

An engineer employed by an ice utility discusses the use of ice for the cooling of small theaters and finds it desirable from a cost standpoint. The paper includes a sample calculation of the cooling capacity required by a small theater of 500 seats. A 57.6 ton capacity of refrigeration and a 60 day operating period with ice at $5 per ton delivered serve as the basis for the author's conclusion that the use of ice instead of mechanical refrigeration is justified in the case considered. The article ends with the following:

"In order to reflect on comparative cost of ice against refrigerating machine equipment, we can safely assume that the cost of refrigerating equipment per ton not including building, but installed, will be about $500. For our example, this means an investment of $28,500 and taking 15% of this amount as yearly carrying charges, this amounts to $4,275 annually, and furthermore, taking the operating cost, we can assume per day of four hour period 20 cents per ton as cost of the electricity alone which for 57 tons and 60 day operation, amounts to $684, and adding to this about $400 for the maintenance, we have minimum yearly cost of $5359, which can be easily rounded out to $6000 if water and other operating costs are added, and the higher class of operating labor considered. Naturally, extending the operating period not only for the sixty days calculated, but also extending the hours of daily operation, the ratios will change. The ice consumption will increase in faster ratio than will the cost of refrigeration by mechanical means, as prolonging the period in this case only direct operating cost will be increased. Nevertheless, the difference will be so great that there is no question that potential customers can easily be convinced of the advantages of the use of ice for air cooling on their premises."

●

Heat Emission from the Surfaces of Cast Iron and Copper Cylinders Heated with Low Pressure Steam

by A. C. Willard and A. P. Kratz

A.S.H.V.E. paper, annual meeting January, 1931. About 5000 words, 1 drawing, 1 photo, 4 tables.

The authors show that a cast iron cylinder with walls 0.25 in. thick will transmit over 50% more heat than a copper cylinder of the same size with 0.01264 in. walls, with low pressure steam on the inside and still air outside the walls.

The iron walls were 20 times as thick as the copper walls and the conductivity of copper per inch of thickness is 8 times that of iron.

By means of tests and calculations the authors show that the reason for the higher heat transmission of the iron is due to the fact that the surface resistance of the copper is much higher than that of iron. This causes a difference in the amount of heat emitted.

By analysis it is shown that the K for cast iron, 0.25 in. thick, painted gray, is 2.30 by calculation and 2.43 by test. For sheet copper, slightly dull, not corroded, the figures are 1.65 and 1.58 respectively. Of the total heat lost from the iron, 321 B.t.u. per sq. ft. per hr.,—205 B.t.u. are lost by radiation and 107 by convection. For the copper the total is 231, with 124 lost by radiation and 107 by conduction. For recleaned copper the heat emission is 144 B.t.u., of which 37 are lost by radiation and 107 by convection.

In other words, neither the thickness nor the conductivity may bear any relation to the heat emission of a cylinder under the test conditions. The surface finish is the factor of prime importance.

●

Canadian Insulation Information

A booklet published by the National Development Bureau, Department of the Interior, Ottawa, under the title of "Building Insulation Industry in Canada, 1930 and Low Temperature Heat Insulation Industry in Canada, 1929."

Contains much detailed information on the scope and nature of the insulation industry in Canada. Figures are included showing the dollar and material volumes of the industry and classifies the totals by the kind of material used, nature of use, etc.

Under the head of trends, the following passage occurs:

"As stated in the 1929 report, the present trend in Canada is definitely toward thicker insulation. In the rigid wallboards where the standard thickness has been 7/16 in. for years, practically all manufacturers are producing and recommending the thicker boards—½ in., ¾ in., 1 in. and even 2 in. The manufacturers of flexible boards and blankets are marketing thicker products, and greater depths of fillers are now being used in buildings. There is, of course, an economic limit, beyond which added insulation does not justify

Copies of books or papers abstracted on these pages should be ordered direct from the publishers.

the increased cost, but we are, in most instances, still far from that limit in Canada."

Research activities in this field during 1930, both by commercial concerns and by public agencies, are described briefly. Several commercial laboratories have made notable headway and the publicly directed studies have advanced. The National Research Council installed a laboratory for making heat conductivity measurements by the hot-plate method.

●

Gas for House Cooling and Air Conditioning

By E. D. Milener

Paper presented before the annual convention of the natural gas department of the American Gas Association under the title "Gas Makes Its Entry into the House Cooling and Air Conditioning Field," Memphis, May 12, 1931. Printed in pamphlet form by American Gas Association, 420 Lexington Ave., New York, 17 pages, 7 in. x 10 in., illustrated.

A report of an activity of one of the association's committees relating to its efforts during 1930 to develop a feasible plan for using gas for house cooling and for air conditioning. Contains a statement of the analysis and reasoning which caused the committee to embark on its program of testing three residences equipped for gas-powered cooling and dehumidifying during 1931. Contains also a fairly detailed description of the cycle of operation of the plants in these three test installations.

After discussing the desirability of a summer gas load, the paper proceeds to a statement of some of the findings of the committee as to the present status of air conditioning. The following interesting statement occurs: "It was also found that there were, within the heating and ventilating industry, several schools of thought regarding the best methods of cooling and dehumidifying air. One school of thought holds that both of these operations should be done only by means of refrigeration. Another school of thought holds that cooling and dehumidifying, being entirely separate operations, should be recognized as such and performed separately and distinctly either by refrigeration or by any other means that present themselves.

"The almost exclusive use of refrigeration for air conditioning up to this time has been probably due to the fact that power has been the sole source of energy that has been available. While cooling can be done directly by refrigeration, dehumidifying can only be accomplished by refrigeration in a very indirect and roundabout manner. Please bear this important fact in mind, that by far the greatest amount of energy required on an air conditioning job is that used for dehumidifying and that the energy used for the necessary cooling of the air is the smallest amount."

Again the paper calls attention to a controversy of long standing in the following words: "The research committee found that there are also several schools of throught in the heating and ventilating profession concerning methods of introducing conditioned air into a room. (Let me say that all authorities agree that the only practicable way to distribute conditioned air is by means of ducts and registers, with the help of fans.) One of these groups holds that air should only be introduced into a room at or near the ceiling and exhausted near the floor. Another group holds that that method, called the downward method of distribution, is not only unnecessary from a technical standpoint but that its general adoption would forever prove a handicap to the ultimate growth of air conditioning by making it impossible to use the thousands of conventional warm-air heating systems now installed. They contend that an upward system of distribution, the kind that has been used in warm-air heating for years, is correct technically in that it takes advantage of the well known fact that as air in a room becomes warmer it rises, and that from a practical standpoint, it immediately makes available for use in summer air conditioning every well laid out warm-air system in the country, possibly with minor changes in the location of exhaust grilles.

"There has recently, in the press, been some rather severe criticism of power-operated, refrigerated buildings in which the air has been conditioned. This criticism has emanated from the public, from engineers, newspaper critics, trade paper writers and others. It has even become a standard joke on the vaudeville stage. It has been contended, that buildings have been primarily chilled instead of being conditioned and that one was literally "hit in the face" by the cold upon entering such buildings and is again "hit in the face" by a hot sultry blast upon leaving the building and going into the street.

"These criticisms have caused the research committee to go quite carefully into the subject and plan all its activities so as to avoid these pitfalls."

Not only does the paper thus repeat one of the oldest criticisms directed at summer cooling but it goes on to present a rather unusual explanation of the cause as follows: "Further, it is true that the contrast between outside and inside conditions is a major factor in deciding what temperatures and humidities should be maintained. Consideration must be given to two classes of people; those who enter the conditioned area for only a short time, and those who spend the entire day in the conditioned space. If the contrast is too great the first class is subjected to two distinct changes, the first on entering the area may not be an unpleasant one except in extreme cases, where the effect is that of walking into a refrigerator; but the second, upon leaving, is a severe one. This latter is generally the result of too great a temperature difference accompanied by a saturation of the clothing, effected by a high moisture content in the conditioned area. This combination of moist clothing and sudden contact with high street temperature finds the body with no means of throwing off the heat load and the effect is quite noticeable. These considerations point to the desirability of an inside dry bulb temperature differing from that of the outside air in the order of about 15° under maximum outside conditions and approaching more nearly to the outside temperature as the latter approaches 80° F. If, in addition to a temperature differential as indicated above, a low relative humidity is maintained, sufficient to insure rapid removal of body moisture, the conditions within the area are extremely comfortable. Not only is the comfort of the transient population of the conditioned area catered

to by reducing the entrance and exit shocks, but further, the resident population is cared for by providing the humidity potential necessary to keep the skin and clothing free of moisture and at a temperature insuring complete comfort. The importance of this dryness factor cannot be too greatly emphasized. Actual observations have shown that a feeling of invigoration is sometimes noticed when one passes into an area wherein the dry bulb temperature is somewhat higher but the relative humidity is considerably lower than that just left. This is only true within certan limits of course, but it is felt that the major part of discomfort attendant to high temperature is caused by accompanying high relative humidity. A consideration of the foregoing would seem to point to an established maximum of 85° dry bulb in the populated zone where the outside temperature is in the order of 100° F. A relative humidity of 40% at 85° temperature will prove comfortable under such conditions.

"Whatever may be established as the maximum conditions to assure the comfort of people within the conditioned area the fact remains that there are two factors which must be positively controlled by air conditioning equipment. These are the dry bulb temperature and the moisture content. The gas air conditioning system which has been developed controls these two factors; the first by means of evaporative cooling or indirect cooling using city water, or refrigeration, and the second, moisture content, by passing the correct amount of air through beds of silica gel which function as dehumidifiers by virtue of the great affinity of gel for water vapor in air."

One of the most significant statements in the whole paper and one worthy of careful thought is: "By definitely recognizing in the very beginning that cooling and dehumidifying are two separate operations and setting out to do them separately, we believe that we are laying the foundation for an entirely new technique in the art of summer air conditioning. It is possible that this new technique will enable air conditioning to be sold to an extent that has not heretofore been dreamed of."

The operating cycle of the installations made in the three residences which are to be studied by the committee this summer is described as follows: "The silica gel gas system for household air conditioning may be said to consist of two essential parts. The first of these is the silica gel adsorption unit to accomplish the dehumidification of the air and the second is the recirculation and cooling system.

"The adsorption unit comprises two adsorbers, a gas operated furnace, an adsorption fan, an activation fan, an after-cooler, a fresh air filter, a gel cooler and necessary dampers, controls, etc. While one adsorber is being used to dry the air, the other is being activated and cooled. This process is carried out alternately and automatically, being timed by an electric clock.

"The adsorption fan draws fresh air through the filter and delivers it to one of the adsorbers where the moisture is removed by the gel. The heat of adsorption which is generated when the water vapor is condensed in the gel is now removed in the after-cooler and the dry air is delivered to the main air stream in the recirculation and cooling system. During this time (normally one hour) the other adsorber is being activated. The hot products of combustion from the gas operated furnace are mixed with sufficient auxiliary air to give a temperature of about 300° F. and this mixture is drawn through the moisture saturated gel by means of the activation fan and exhausted to the outside atmosphere. This, of course, drives the moisture from the gel which must then be cooled before being placed in service once more. A damper shifts and the furnace shuts down. The fan now recirculates air through the hot gel and the gel cooler. The heat is removed by water circulation in the coils of the gel cooler and when the gel is cooled it is again ready for service.

"The cycle is, of course, controlled automatically. One small toggle switch is placed conveniently on the first floor. When this is closed, the two motors start, the water is turned on and the unit continues to run until the switch is again turned off. The unit is entirely self-contained and presents a neat appearance. So much for the dehumidification equipment.

"It will be appreciated that a large flow of air is needed to properly ventilate and cool the house and this is supplied by means of the recirculation system consisting of the supply and return ducts, the main air-filter, the main fan and the main cooler. These are connected direct to the furnace by means of appropriate ducts. The air is drawn from the house through the return ducts and is mixed with the very dry air from the silica gel adsorption unit. The mixture then having the proper moisture content for comfort, is drawn through the filter and thoroughly cleaned. The air then passes through the main cooler where it is cooled to the proper temperature and is then delivered to the head of the furnace where it is distributed in the various supply ducts to the rooms of the house, the same as warm, moist air is distributed in the winter. The cooler is of the indirect type, water being circulated through tubes and the air in passing over the tubes gives up its heat to the water. An alternate method of cooling is by means of a gas refrigerator and coils. A second toggle switch is placed on the first floor to turn the main fan off or on as desired. Thus the two functions of drying and cooling are done entirely independently of each other and either one or both may be used at the pleasure of the householder. Proper relays and safety devices are employed to make the equipment foolproof. It is designed to provide moderate temperature difference from outside to inside, say 85° F. on a 95° F. day. This will avoid chilling of occupants, but the relative humidity will be kept below 50% to insure perfect comfort."

●

Flow of Liquids in Pipes of Circular and Annular Cross Sections

by Alonzo P. Kratz, Horace J. Macintire and Richard E. Gould

Bulletin No. 222 of the Engineering Experiment Station of the University of Illinois, 26 pages, Illustrated. Obtainable by addressing the station at Urbana, Illinois. Price, 15c.

The results of laboratory studies on the flow of water and brine through pipes. Specifically a study of the

relation between Reynolds' number and the friction factor for two sizes (1¼ in. and 2 in.) of standard wrought iron pipe, and for channels of annular cross sections.

The following passage is of interest: "The results of these tests . . . are indicative of the fallacy that exists in adopting a single value for either the length of pipe equivalent to an elbow, or the ratio of head lost to velocity head in the pipe, and in using such adopted values over a wide range of conditions. The curves show varying values for both of these quantities ordinarily used as constants in estimating the friction loss in pipe lines."

●

Study of Performance Characteristics of Oil Burners and Low-Pressure Heating Boilers

By L. E. Seeley and E. J. Tavanlar

A paper presented at the eighth annual convention, American Oil Burner Association, Philadelphia, April, 1931.

Deals with a study made at Yale University in which several oil burners were tested in various makes of heating boilers. While it was apparently intended that all the boilers used should be capable of producing essentially the same result, the actual physical dimensions were by no means similar. The oil burners used are not described in enough detail to make it possible to identify them, but they were evidently not alike in operating characteristics at least.

The report separates the tests into seven series. In each series some desired objective was set up and some or all of the operating characteristics were studied. Two series were devoted to continuous tests with No. 1 oil and with No. 3 oil. One test (one series) consisted of a single study of the effect of a draft change on the operating characteristics, and another consisted of a study of the effect of a CO_2 change. Two series of tests were conducted with intermittent operation of burners. One series differed essentially from the other in that a greater draft was used. Sound measurements were made during the tests to record some of the sound characteristics.

The testing set-up was patterned largely to agree with tentative codes on the subject and was arranged for either intermittent or continuous tests.

The tests were not intended to shed any light on questions of safety in operation or on the desirability or necessity of automatic control features in operation, but were confined largely to operating characteristics as regards the oil-burning and heat generating features only. Thus, the intermittent tests were conducted with off and on intervals arbitrarily set rather than those actually found in operating plants. So, also, the sound measurements did not necessarily indicate the sound characteristics of an operating plant.

The authors prepared many charts and graphs to show the principal results. In the main, however, while very interesting, these charts do not contain fully digested information for actual application since they show the results for the conditions of the tests only. The summarized results follow:

(1) The general shape of the boiler efficiency curves remains the same with various oil burners. (2) The efficiency values for a given boiler are not necessarily equal for various oil burners even when the oil burners are operating in practically the same manner in each case. (3) The radiation and unaccounted losses average higher for some boilers than others. (4) Some burners also show higher radiation and heat losses than others. (5) All other things being equal an increase in draft: (a) lowers boiler efficiency (b) lowers CO_2 (c) increases excess air and (d) increases flue temperatures. (6) All other things being equal a decrease in excess air when CO_2 is 10% (a) increases CO_2 (b) increases efficiencies moderately and (c) decreases flue temperatures. (7) Efficiency curves on intermittent type of operation all show the same characteristic shape. (8) Intermittent operation at different drafts shows that some burners are more sensitive to draft fluctuations than others. Item (5) also indicates the same characteristic. (9) Efficiencies tend to rise with a decrease in heat absorption rate of boiler per square foot of heating surface, although some types of burners will give good results at higher rates than others. (10) Increase in boiler heating surface for the same fuel burning rates will show higher efficiencies. (11) Heat liberation rates in furnaces vary quite widely, averaging higher for some oil burners than others. There seems to be no such thing as a desirable fuel burning rate per cubic foot of furnace volume for oil burners in general. (12) On sound tests some burners make measurable combustion sounds but it does not necessarily follow that such a burner may not be more quiet than one giving no combustion at all.

●

The Amelioration of Atmospheric Pollution

By H. W. Green

American Journal of Public Health, March, 1931, 5 pages, approximately 2000 words. A paper read before the association in October, 1930.

Treats the subject from the standpoint of all the sources of pollution of which the smoke from stacks is but one. Mentions the very great diversity of solids in the air as shown by samples collected in Cleveland. These samples over a 24-month period showed an average deposit of solids of 119 tons per square mile per month. Points out the great amount of sulphuric acid which may be expelled to the atmosphere from stacks and processes. Much of the paper is devoted to smoke elimination principles and practices. A comparative statement of the relative amounts of Fe_2O_3 found in samples taken from industrial and residential areas is given as follows:

Region	Tons of Fe_2O_3 per sq. mile per month
Industrial	28
	17
	14
Residential	6
	5
	4

Your Everyday Problems

Mr. Hanburger will be glad to answer your problems relating to installation and operation of heating and ventilating systems, and wherever possible will give the reasons for his suggestions. Letters will be answered direct to the inquirer and in some cases published anonymously. If sketches are included they should be clearly drawn. Write Mr. Hanburger care of HEATING AND VENTILATING, 521 Fifth Avenue, New York.

Conducted by FRED W. HANBURGER

QUESTION 6. Can I obtain a friction pressure loss chart for brass or copper pipe? I have been unable to find one and find myself hesitating to use this type of piping in many instances due to a lack of knowledge of the friction created. A series of tests or a formula would help me if such are available.

ANSWER. Inquiries among manufacturers and distributors of brass and copper pipe have failed to bring to light a chart of this nature. A rather loose rule is to take the friction loss as 10% less than that for new steel pipe. I have always felt that it would be less than this. With only a decrease of 10% in the friction it hardly warrants the practice of using one size smaller in brass pipe than we would in that of iron or steel. It is easily conceivable that a chart of this nature would result in the increased use of brass and copper piping.

QUESTION 7. Does a can of water kept on the radiators help in keeping the air moist? How much water should be evaporated in the average apartment? How can I determine this amount?

ANSWER. The widow's mite when contributed to a worthy cause becomes glorified and shines out in greater brilliance than large gifts of the rich but there is nothing glorified in the tiny moisture contribution of the tin can setting on a radiator although it does shine out in all its ugliness. There are many worthy humidifiers on the market at a reasonable cost which will not destroy the beauty of the room and which will evaporate a sufficient amount of water.

The amount of moisture needed for the average apartment will vary greatly. In many where there is a much used kitchen there may be no need of any humidification. Possibly an easy method of estimation will aid you and you can then determine the amount required to suit your needs. Let us assume an apartment with a cubical content of 10,000 cu. ft., to be heated to 70° with 40% humidity. Referring to the steam tables it is found that the volume of one pound of 70° steam is 871 cu. ft. As there are 7000 grains to a pound, the amount of moisture in a cubic foot of steam and therefore in a cubic foot of 70° air when 100% humid, for they both occupy the same space, will be

$$\frac{7000 \text{ gr.}}{871 \text{ cu. ft.}} = 8.3 \text{ gr.}$$

At 40% humidity the amount will be

$$0.40 \times 8.3 = 3.3 \text{ gr.}$$

Similarly, the amount of moisture in the outside air may be ascertained. Assuming a case of 20° temperature and 50% relative humidity, the air will have 0.5 gr. per cu. ft. Disregarding the expansion of the air when being heated, there must then be

$$3.3 \text{ gr.} - 0.5 \text{ gr.} = 2.8 \text{ gr.}$$

of moisture added to each cubic foot of incoming air. If we allow one air change per hour the apartment would then need

$$\frac{2.8 \text{ gr.} \times 10{,}000 \text{ cu ft.}}{7000 \text{ gr.}} = 4.0 \text{ lb.}$$

or about ½ gal. per hr. The little tin can will not evaporate this much in a day. For more precise calculations the moisture content is estimated per pound of air rather than on the cubic foot basis.

QUESTION 8. I notice that tables for pipe sizes in standard texts are generally based on a pressure drop of 1 oz. per 100 ft. of run but for less than this drop for the risers. Should they not be on the same basis?

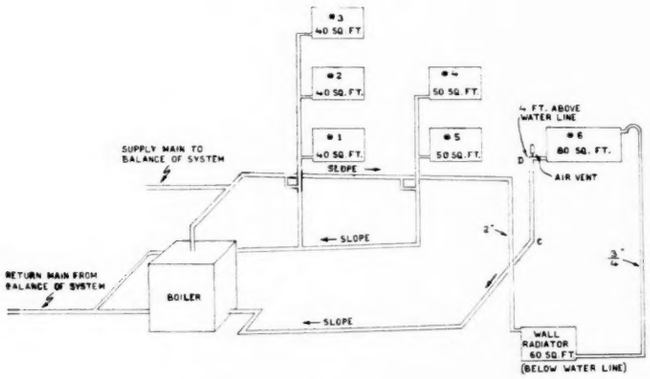
ANSWER. If the risers in a one-pipe system were based on a pressure drop of 1 oz. per 100 ft. of pipe it would be apt to be noisy owing to the velocity of the steam being so great as to carry the water of condensation with it. This fact is the basis upon which the risers are sized. If you will look up the tables for the vapor systems you will find that the sizes given have generally a drop greater than 1 oz. owing to the fact that there is not nearly so much condensation returning against the steam flow.

ANSWER to B. McL. The use of iron or steel fittings in connection with your brass pipe work would defeat the purpose for which you are using the brass pipe as the combination of the two metals would induce an increased hydrolytic action.

QUESTION 9. I am submitting a sketch of a garage heating layout, the garage being in the lower part of the wing of a house. The garage is lower than the cellar in which the boiler is located and its wall radiator is at least two feet below the boiler water line. I first tried to heat this radiator with the condensation by running all the returns from radiators 1, 2, 3, 4, 5 and 6 through it but it was not efficient. A friend of mine advised the steam connections as shown claiming he had seen one in operation. The only way I can get heat now is to tap the water from the garage radiator every so often. Can you tell me what is the trouble?

ANSWER. There have been several queries of a like nature and in each case the failure seems to be a lack of appreciation of the principles involved, so that a detailed discussion may be of interest. In the other cases a simple alteration gave the proper correction. In your case it is felt that it would have been best to have continued it as a hot water radiator and this will be discussed later. If steam radiation must be used the layout should be as shown in the drawing.

The usual description of the operation of this connection that the rapid condensation of steam in the



Layout of garage heating system

upper radiator creates a vacuum, causing the steam to rush up the riser with sufficiently high velocity so as to carry all the water of condensation with it is somewhat misleading. In general, there should be no vacuum created in the upper radiator as this condition would entail a greater water line difference in the return riser CD than usually obtains. Notice the thermostatic air vent at V. There must of necessity be a rather large pressure differential as will be shown later. Again the steam will not condense any more rapidly in this radiator than it would in any other radiator of like size in a room of 70° temperature. Allowing a quarter pound of steam for each sq. ft. of radiation there will be condensed just $\frac{80 \text{ sq. ft.}}{4} = 20$ lb. of steam per hour and it is on this condition we must design our piping. The riser to the extreme right must be restricted sufficiently so that the 20 lb. of steam to the upper radiator will have sufficient velocity to carry the condensation of the lower radiator with it. The velocity formerly was a matter of conjecture until tests indicated that in the smaller pipe it is between 30 and 40 ft. per sec. Taking a value of 25 cu. ft. of steam per lb. there would be needed in this case

$$20 \text{ lb. x } 25 \text{ cu. ft.} = 500 \text{ cu. ft. per hr.,}$$

or

$$\frac{500 \text{ cu. ft.}}{3600 \text{ sec.}} = 0.14 \text{ cu. ft. per sec.}$$

and adopting a velocity of 40 ft. per sec. the area of the riser AB would need be at or less than

$$\frac{0.14 \text{ cu. ft.}}{40} = 0.0035 \text{ sq. ft.}$$

This lies between a ¾ in. and a 1 in. pipe. The ¾ in. size would be safest so that this is used.

The next consideration is the water line difference, or height above the water line, in the pipe CD. The friction loss or pressure drop through the riser to the right will be about 1 lb. per sq. in. The steam pressure in radiator 6 will be one pound less than the boiler pressure and the water will rise in CD until this difference is balanced. This will require 2.5 ft. alone and to allow for a heating up period it should have at least 4 ft. Under these conditions the system should function satisfactorily. The returns from radiators 1, 2, 3, 4 and 5 should be returned with the balance of the system as shown on the sketch, leaving the circuit to the garage and radiator 6 separate.

In a layout of this nature with the water carried along with the steam there will be noise and it might have been better to have continued its use as a hot water radiator using the returns from the whole system to supply it. The reason it failed was that the condensation from the six radiators mentioned was not sufficient to supply it. To estimate the amount of upper radiation needed to supply the garage radiator is a matter of simple arithmetic. The heat emission from the 60 sq. ft. will be

$$60 \text{ sq. ft. x } 240 \text{ B.t.u.} = 14400 \text{ B.t.u.}$$

The condensation from the upper radiators will flow through the 1¼ in. return with an average of only about 2 ft. per min., taking approximately ½ hour to reach the garage radiator so that its temperature will hardly be over 180°. After its temperature drops to 110° its value as a heating medium in cold weather is practically nil. We can then base our estimation on only a 70° temperature drop or on 70 B.t.u. from each pound of water flowing. There would then be needed

$$\frac{14400 \text{ B.t.u.}}{70 \text{ B.t.u.}} = 206 \text{ lb. of condensation,}$$

to supply the garage radiator. Taking a value of ¼ lb. from each sq. ft. of radiation there would be needed

$$206 \text{ lb. X } 4 = 824 \text{ sq. ft. of the upper radiation.}$$

With the low temperature of the water the heat emission will be but about 120 B.t.u. per sq. ft. and the garage radiator would then need be increased to

$$\frac{14400 \text{ B.t.u}}{120 \text{ B.t.u.}} = 120 \text{ sq. ft.}$$

just twice the amount as when used for steam.

News of the Month

Newark May Have District Heating

Plans for organizing a district heating plant in Newark, N. J., were made public April 28 when articles of incorporation were filed with the county clerk in Essex and the Secretary of State in Trenton by the Newark Steam Company. The incorporators are Thomas N. McCarter, Percy S. Young and Edmund W. Wakelee, president and vice-presidents, respectively, of the Public Service Corporation of New Jersey.

The concern will be a subsidiary of the Public Service Electric and Gas Company. By its charter it will be authorized "to produce, manufacture, buy, sell, accumulate, store, transmit, furnish, supply and distribute steam heat and power within the city of Newark, Essex County, New Jersey."

O. P. Harris to Head Oil Burner Dealers

The board of governors of the newly organized dealer division of the American Oil Burner Association has appointed Oliver P. Harris to act as managing secretary of that division. Mr. Harris has been director of sales training for several nationally known manufacturers.

Gas Pipe Line for Central Pennsylvania

Plans are being made by the Pennsylvania Power and Light Company to lay a new pipe line from Tioga, Pa., to Williamsport and points south for distribution of the newly discovered supplies of natural gas in the Tioga field. Williamsport is now supplied with manufactured gas.

New Bookkeeping System for Small Shop Offered by P. & H. I. B.

To meet the need of the smaller plumbing and heating contractors for a simple bookkeeping system which can be handled, if necessary, without a bookkeeper the Plumbing and Heating Industries Bureau has devised a new system known as the standard general accounting system.

Like all other bookkeeping materials, this new system is sold to contractors at cost. Because of the volume of the business done by the bureau with the 8,000 contractors who are using some or all of the forms, the bureau's costs are low. The new system is sold complete for $15.

Westinghouse Builds Experimental Room for Study of Radiant Heating

Announcement was made last month by the Westinghouse Research Laboratories, East Pittsburgh, Pa., of the completion of a room for studying methods of radiant heating. The work is under the direction of L. W. Schad, who plans to study the feelings of a number of individuals each of whom will spend some time in the room experiencing a series of temperature levels, humidity changes and ventilation currents.

The room is heated by a surface in which is embedded electric heating elements. All the heat comes from walls and ceiling. The entire surface may be warmed, or the heat merely switched on section by section where it will do the most good. These walls radiate a mild temperature almost exactly equal to that of the human body and feel barely warm to the touch.

The new room will be tested with air quite cool to learn whether the heat radiated by the body in all directions can be used for both comfort and a possibility of saving in fuel bills.

Cold walls absorb this radiated heat rapidly. Whether the lesser absorption of mildly heated walls will produce a worthwhile difference in physical comfort is one question the new room is designed to answer.

University of Utah Teaching Heating and Combustion by Mail

Ninety-two students from twenty-three states are enrolled for the correspondence course on combustion and heating of the University of Utah, according to the April report of the extension department.

The course comprises twelve lessons prepared with a view to meeting the need of the practical man, containing simple technical instruction on heating problems and ordinary situations encountered in burning coal. The first six lessons include history and composition, mining, chemistry and analysis, storage, sampling, combustion, by-products, etc.

A.S.H.V.E. Research Program for Year 1931 Announced

According to a recent announcement by the committee on research of the American Society of Heating and Ventilating Engineers, the research program of the society for the coming year will include investigations on the following subjects:

1. Atmospheric dust and air cleaning devices.
2. Air conditions and their relation to living comfort.
3. Physiological effects of atmospheric environment on human beings at work.
4. Heat transmission through building materials.
5. Conductivity studies on concrete.
6. Heat capacity of concrete slabs.
7. Heating effect of the sun on building roofs and walls.
8. Infiltration of air through walls and building openings.
9. Boiler testing with oil fuel and rating of oil burners.
10. Measurement of air flow through registers and grilles.
11. Characteristics of copper tubing for steam and hot water.
12. Performance characteristics of various enclosed types of cast iron and non-ferrous radiators under actual heating service conditions.

The budget for 1931 research has been set at $43,750, over $3000 more than was spent during 1930, and $10,000 more than was spent during 1929.

Purdue Stoker Tests Available

According to an announcement by H. A. Glover, chairman of the Committee of Ten of the Coal and

News of the Month

Heating Industries, complete data from the stoker tests recently conducted at Purdue University through the cooperation of the Indiana Coal Operators Association will be available about June 1. Tentative arrangements have been made with the university for further tests intended to reveal comparative efficiencies and costs of stoker-fired coal with competitive fuels.

Recommendation will be made by the Committee of Ten to the Illinois Coal Bureau and the National Warm Air Heating Association for a cooperative arrangement for stoker-fired Illinois coal and competitive fuel tests to be made at the University of Illinois.

A.S.H.V.E. Laboratory Procedure Reorganized

Announcement has been made by C. V. Haynes, chairman of the committee on research by the American Society of Heating and Ventilating Engineers, that in line with the policy approved by the research committee, A. C. Willard, head of the Department of Mechanical Engineering and professor of heating and ventilation at the University of Illinois, has been retained as technical advisor for research by the society.

Centralized control is continued through the chairman of the committee on research with the assistance of the technical advisor. The director of the reasearch laboratory will have charge of all investigations at the society's laboratory in the Bureau of Mines Experiment Station, Pittsburgh.

The announcement sets at rest numerous rumors which have been circulated regarding future activities and procedure in the society's laboratory.

Professor Willard is a past president of the A. S. H. V. E. and has been on the staff of the University of Illinois since 1913. During the war he acted as consultant on heating, cooking, and laundry equipment for the United States Army, and since 1920 has been head of the Department of Mechanical Engineering at Illinois. He was associated with the design of the Holland Tunnel as consultant on ventilation; has acted as consultant for the architect of the Capitol at Washington in planning the ventilation of the House and Senate chambers, and is also acting in a consulting capacity for the Chicago subway. He has been in charge of investigations in warm-air furnace research for the past 11 years for the National Warm Air Heating Association and investigations conducted for the National Boiler and Radiator Manufacturers Association and the Illinois Master Plumbers Association.

Professor A. C. Willard

Cooperative arrangements for research are now in effect with the following institutions: United States Bureau of Mines, Armour Institute of Technology, Carnegie Institute of Technology, Harvard University, Texas Agricultural and Mechanical College, University of Illinois, University of Minnesota, University of Wisconsin, Washington University, (St. Louis), and Yale University.

Cities Adopt New Oil Burner Ordinances

Effective April 8, the city of Mount Vernon, New York, adopted a new ordinance applying to oil burners. The new ruling will permit one 275 gal. exposed tank, gravity feed and copper tubing. Copies of the new ordinance will be available in the near future.

Ann Arbor, Mich., recently adopted a new ordinance which is identical to the enabling act for the state and conforms very closely to the model ordinance of the American Oil Burner Association.

The association reports that it recently received letters approving the model ordinance from the following fire insurance rating organizations: Schedule Rating Office of New Jersey, New York State Organization in Syracuse and the South Eastern Underwriters Association.

Cyril Ainsworth New Assistant Secretary of A. S. A.

Cyril Ainsworth, formerly safety engineer on the staff of the American Standards Association, has been appointed assistant secretary of the association to succeed F. J. Schlink, whose resignation was recently announced.

Twenty-Second Convention of N.D.H.A. to Be Held in Boston

The 22nd annual convention of the National District Heating Association will be held at the Statler Hotel, Boston, June 2-5. The program follows:

JUNE 2

2:30 p. m. Report of research committee, by E. E. Dubry. Report of operating statistics committee, by A. D. Leach. Report of station operating committee, by H. J. Bauer.

8:00 p. m. Report of meters and accessories committee covering use of stainless steel drums, giving tests on condensation meters and also covering shunt meters, by J. J. Schenk. "Condensation Meters, Covering Their History, Development and Performance," by B. M. Conaty. "Steam Flow Meters," by H. M. Hammond. Hot water committee report, by S. F. Delany.

JUNE 3

9:30 a. m. Report of commercial relations committee, by S. S. Sanford. "An Outline of Refrigerants and Refrigeration Systems Used in Air Conditioning," by R. W. Waterfill. "Steam as an Activating Agent for Silica Gel Air Conditioning," by H. R. Warfield, Jr. Report of rates and regulations committee.

JUNE 4

9:30 a. m. Report of distribution committee, by Edward Lenz. "Research Developments in Corrosion," by James Aston. "Methods of

Welding Pipe," by E. R. Benedict. Report of committee on corrosion, by J. H. Walker.

JUNE 5

9:30 a. m. "Sales Promotion in District Heating," by Harry T. Bussman. Report of sales promotional committee, by J. W. Meyer, N. S. Wade, J. E. Seiter, William J. Baldwin, Jr., and H. L. Martin.

At the opening session, 10 a. m., June 2, the president's address will precede the presentation of the reports of the financial condition of the association, executive committee, educational and the new handbook committees and manufacturers' division.

At the Thursday morning session, June 4, the "Manufacturers' Round Table" will be held at which a paper on "The Development of a New Form of Underground Steam Main," by C. Gottwald will be presented, and the report on recent distribution installations made by the American District Steam Company will be reported by Arthur J. Slade and H. E. Moore, of that company.

Total Expenditure of Nearly Half Billion Involved in Federal Building Program

Tabulation of government public building projects under way at the request of President Hoover revealed that a total expenditure of $429,604,364 is involved, the largest amount at any single time in the history of the United States. This is on top of construction of fifty-one Federal buildings costing $23,516,816 during the last two years.

The present speeding of construction is a direct result of liberal appropriations by Congress made in order to relieve unemployment. Although a new peak in labor employment on public projects already has been reached, actual construction on many of the 707 buildings planned has not yet begun, and an even larger number of men will be employed later in the year.

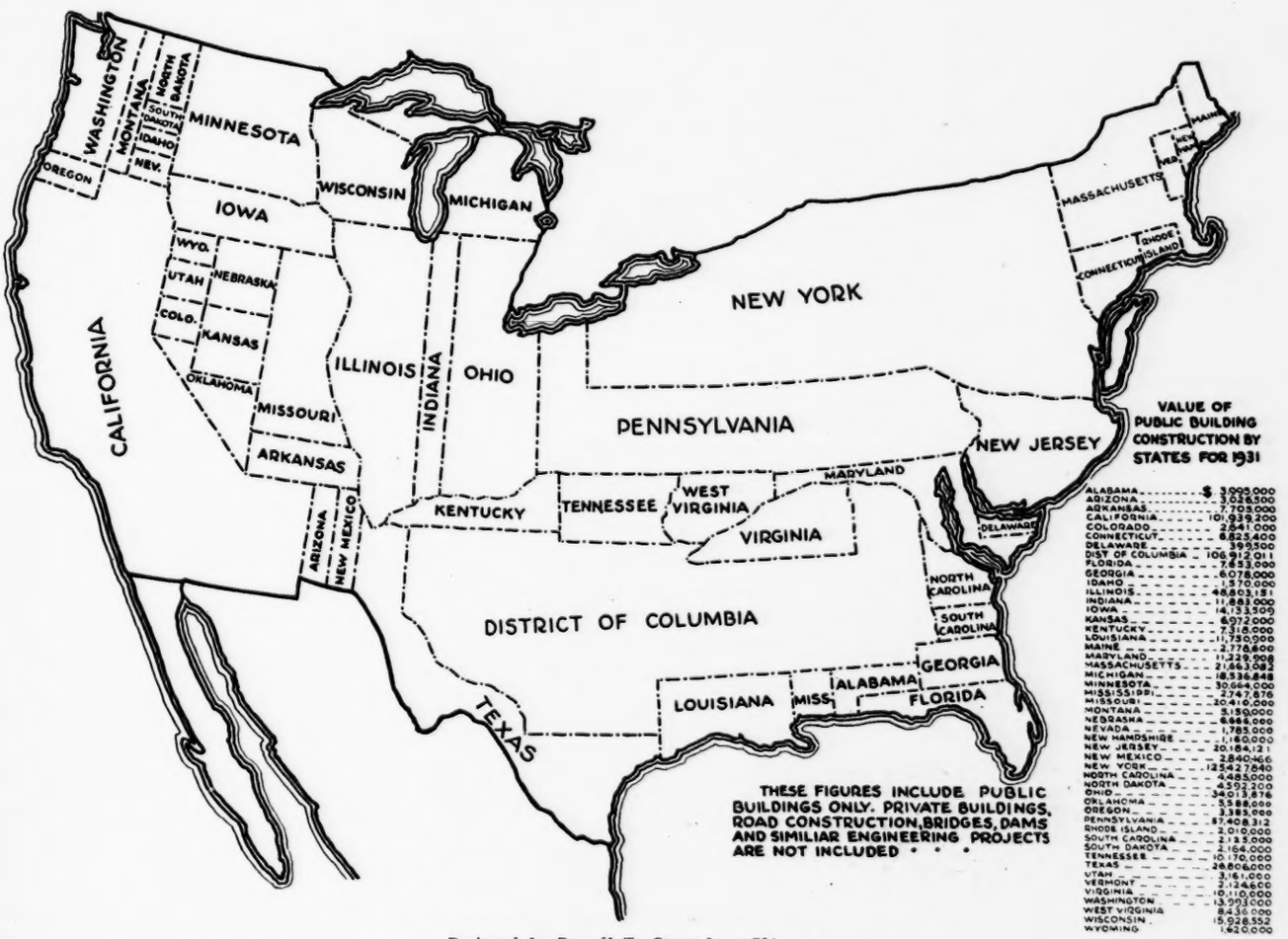
Government engineers are blasting and building from Maine to California and from North Dakota to Mississippi. Total expenditures of $64,000,000 will be made in New York State alone. Federal projects now in process or planned for New York include a parcel post office, assay office, warehouse, post office, courthouse and an addition to the courthouse in Brooklyn.

Some of the larger projects include: Post office, Brooklyn, N. Y., $2,700,000; parcel post office, New York, $11,000,000; assay office, New York, $3,765,000. Camden, N. J., $1,100,000. Trenton, N. J., $1,650,000. Washington, Department of Agriculture building, $12,800,000; Department of Commerce building, $17,500,000. Post office, Boston, $6,000,000. Louisville, Ky., $2,985,000. New Orleans, La., $2,000,000.

Among the larger projects still in the specification stage or not yet let for bids are included the Department of State building in Washington, involving $3,000,000.

Projects where sites have been ac-

News of the Month



Designed by Russell T. Gray, Inc., Chicago.

Distorted map of the United States, areas of each state being in exact ratio to the value of public buildings planned for 1931.

quired and plans are partially completed include: New York post office annex, $9,500,000; marine hospital, $2,500,000; court house, $10,700,000. Newark, N. J., $6,150,000. Washington, archives building, $8,750,000; central heating plant, $4,857,000; Coast Guard building, $3,000,000; Labor Department, connecting wing, $4,750,000; Interstate Commerce Commission building, $4,500,000; Justice building, $12,000,000.

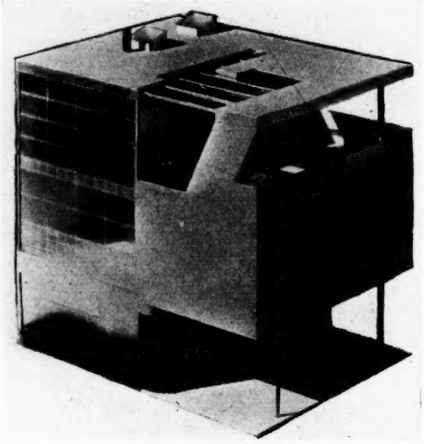
Aluminum House Exhibited in New York

A house designed to give house dwellers better light and air with mechanical conveniences and efficiency of arrangement that are unheard-of features of the average suburban dwelling was exhibited at the Architectural League Show and Allied Arts Exposition at Grand Central Palace, New York, April 18-25, 1931. It was designed by A. Lawrence Kocher and Albert Frey.

The house was built with an extremely light framework of metal with a manner of construction suited to standardization. The walls were faced with aluminum in the form of sheets slightly ribbed to break the glare and to care for expansion and contraction. The aluminum was backed with heat insulation. Windows of ultra-violet glass extended the entire width of the rooms so as to admit plenty of light.

The house was heated with an oil-fired boiler specially designed for oil, a steam heating system being used in connection with specially designed aluminum radiators. The garage was heated by a unit heater.

The main living rooms were above the ground level reached by a short flight of stairs. The ground floor served as entrance, boiler room and garage, and also as a porch within the ground area relating to the garden. The house could



Aluminaire house.

be entered either by way of the garage or the front doorway.

The living floor, corresponding to the second floor of the usual house, was duplex and extended through the width of the house with one end entirely glazed from floor to ceiling, a height of 17 ft. At the other end was a dining area which can be converted into additional living space. The room was illuminated by Neon lighting, the tubes running parallel with the head of the window so that with reflectors the night lighting in its source corresponded to daylighting. By turning a dial one could obtain a clear white light suggesting the quality of daylight or a selection of color. The rooms were also equipped with sun ray lamps, radio and other electric devices.

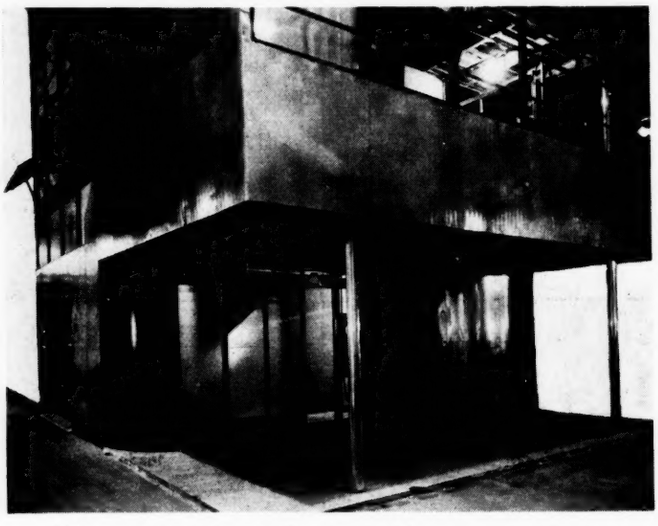
The bedroom, exercise room and bathroom were separated by a folding partition. With the partition folded the outlook of the window was 22 ft. in length.

The house is said to be the first all-metal house attempted in America, even the supports consisting of thin aluminum columns. These columns supported cantilever beams from which the outside walls were suspended. The total weight was one-twelfth the usual weight of a house built with concrete and steel.

The house was not greeted enthusiastically by all those who viewed it at the show. Among the comments was that of Maurice S. Goodman, managing director of a Westchester County development, who described the habitation as "fit only for robots in a mechanistic age which we have fortunately not reached."

"This metal house," said Mr. Goodman, "is offered for its 'higher efficiency,' for its 'economic construction, which is made possible by the standardization of parts in houses of certain dimensions, which parts can be replaced as readily as the worn or broken-down parts of a flivver.' Who is interested in buying a home for its efficiency and economic possibilities only when that home must be an eyesore both to him and to the community? What man who moves to the suburbs where he may live less expensively and enjoy a home and environment which satisfy his tastes in comfort and beauty could find contentment in this monstrosity entirely out of keeping with the sloping lawns and sheltering trees of a suburban landscape? Such a house would be ruinous to a community development designed to enhance the landscape, not to mar it.

"Nothing in art or in music or in literature succeeds merely because it is different; nothing in architecture can succeed on the basis of efficiency only—it must appeal in some degree to a man's aesthetic sense—a sense often painfully undernourished."



View of the Aluminaire house from ground floor.

Southwest Makes Complaints on High Gas Bills

A revolt among gas customers in the southwest against alleged high gas bills took place during the closing months of the heating season, according to *Natural Gas*, the official publication of the natural gas department of the American Gas Association. The protests were not confined to any single locality but were noted all the way from Little Rock, Ark., to the Rio Grande. The conditions responsible for the situation were: the economic depression, a mild winter following a severe winter last year, and the apparent over-abundance of natural gas in Oklahoma and Texas. Municipal ownership of the utilities was strongly urged in some localities.

However, as warm weather approached the complaints and controversies gradually died down. The large companies have not reduced their rates to domestic customers and in no instance, according to the publication quoted, have the moves for municipal ownership been brought to final fruition.

British Parliament Members Ask for Better Ventilation

Report comes from England that a petition to the First Commissioner of Works, asking for better ventilation of the House of Commons, is being signed by members of the Parliament. Over 100 members have signed the petition, which states:

"We would like to bring to your notice a commonly expressed complaint as to the devitalizing effect of the atmosphere in the House, not only in the Chamber but in the libraries and other rooms; and the general conviction that this is due to the present system of ventilation.

"We believe that, in the interests of the health and efficiency of the members of the House a thorough investigation of this matter should be undertaken as early as possible and we therefore urge you to authorize an inquiry by independent experts."

New Plant Will Heat 26 Government Buildings

Further details of the big government heating plant which is to be built in southwest Washington between C and D and Twelfth and Thirteenth Streets, were made public May 12 by the United Engineers and Constructors, Inc., of Philadelphia, architects and engineers, whose selection was announced recently by the Treasury Department. This firm is to draw plans for the new plant.

The plant will supply heat to twenty-six government buildings, including structures both north and south of the Mall and lying in the general area of the huge triangle bounded by Pennsylvania Avenue Northwest, Maryland Avenue Southwest and Fifteenth Street. It will not serve the Capitol group.

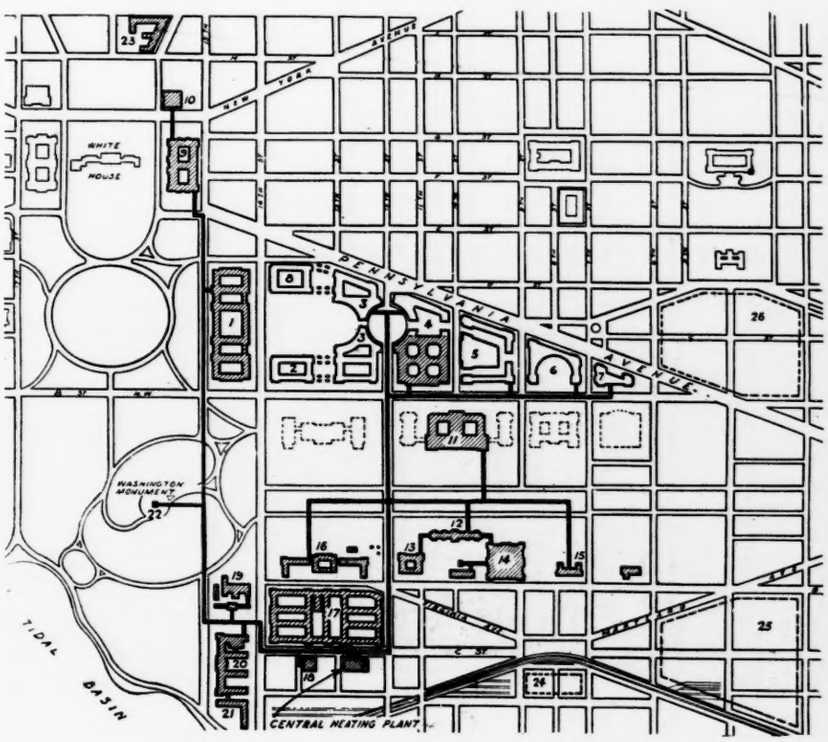
In an average year these buildings will consume 1,500,000,000 lb. of steam. The new heating plant will provide 75% of that capacity and will be designed to permit of further extensions.

Steam will be distributed to the buildings through an underground system of pipes varying in diameter from 3 in. to 18 in., with an aggregate length of approximately five miles.

The buildings to be served by the plant will include the Department of Commerce, Department of Labor, Government Auditorium, Interstate Commerce Commission, Post Office Department, Internal Revenue Bureau, Department of Justice, Archives, Coast Guard, Treasury Department, Treasury Annex, buildings to replace the present District Building, new National Museum, Smithsonian Institution and miscellaneous small buildings, Freer Art Museum, Old National Museum, Army Medical Museum, Department of Agriculture, Agricultural Extension Building, Agricultural Economics Building, Auditor's Building, Bureau of Engraving and Printing, Liberty Loan Building, Washington Monument, Veterans Bureau, proposed Federal warehouse, and the Municipal Center.

Committee of Ten to Study Stoker Sales

An analysis of sales of stokers and various types of solid fuel burning equipment and a study of smoke abatement and of the possibilities of increasing the use of solid fuels in the domestic heating field are to be undertaken by the Committee of Ten, Coal & Heating Industries as a result of the April meeting of the Committee held at Columbus, Ohio, in conjunction with the annual con-



Layout of district heating plant for Washington.

vention of the National Warm Air Heating Association.

Also included in the program, recommended by the commercial research section of Market Research Institute of the National Coal Association, is the continuous study of competitive fuels, equipment and methods of meeting such competition. Some of the work will be undertaken direct but a large share of the data will be supplied by member organizations for assembly and analysis by the committee, which will report back its analyses and findings to the related industries.

Spitzley Elected President of H. & P. C. N. A. at Annual Convention

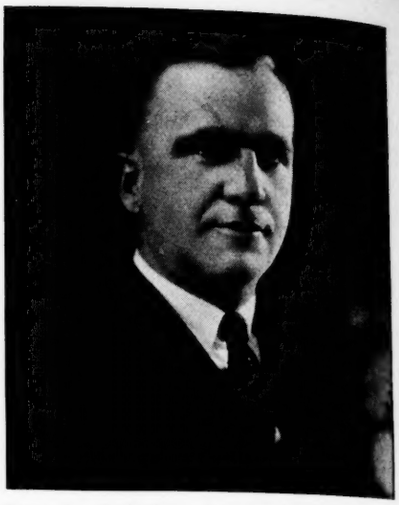
Ray L. Spitzley, of Detroit, was elected president of the Heating and Piping Contractors' National Association at the 42nd annual convention of the association, held in Louisville May 6-9. The convention was one of the most successful held in recent years in spite of a slight falling off in attendance, which reached a total of nearly 500.

John C. Howell, of the Associated Consulting Economists, struck the keynote of the convention in his interesting address in which he reviewed the current depression in the light of the buyer's purchasing power and the basic factors which should make for a renewal of activities. Mr. Howell felt that because of the soundness of underlying conditions the depression could not long continue, and while adjustments would be necessary there was no doubt of the eventual upturn. The convention reflected this viewpoint and there was a feeling throughout that while conditions were not rosy now it is a time to take stock and to lay plans and put the house in order.

The reports of the several committees showed that earnest work is being done and careful thought is being given to the problems of the association's membership, including ways and means of increasing business, of helping the contractors to develop merchandising plans, and to develop standards and keep abreast of developments.

The first public information as to the results being secured through the association's merchandising plans was announced. It was revealed that as a direct result of the first two months of operation of the plan a total of 183 jobs valued at slightly over $200,000 had been secured. The secretary's cup to the local association which secured the greatest volume of business through the plan was awarded to the Cleveland association for 47 jobs valued at $80,264. Much interest was shown in the merchandising plan and manufacturers participating in the discussion of the committee report agreed that it was both desirable and sound.

Walter Klie, the retiring president, in his address appealed for continued support of the association's major activities as being a logical way to proceed in the right direction through a period of dullness.



Ray L. Spitzley, newly-elected president of the H. & P. C. N. A.

The secretary's report reviewed the work of the past year and pointed to the constructive projects undertaken, the launching of the merchandising plan, the expansion of the official bulletin, the increased scope of the educational work and the plans for the coming year.

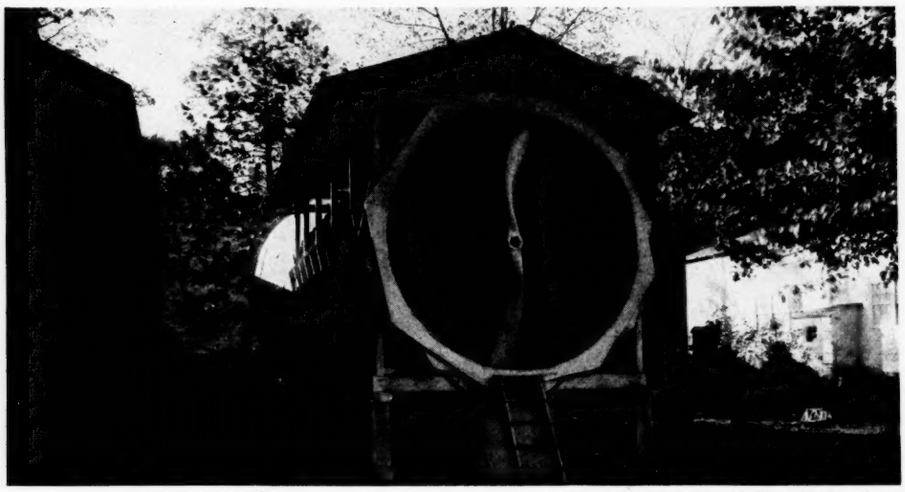
The standards committee reported steady progress both in the actual formulation of its work and in the collection of data preliminary to the setting up of standards.

Professor A. C. Willard explained some of the results obtained from his work on rooms heated by radiators.

The Plumbing and Heating Industries Bureau contributed interesting demonstrations on the use of the telephone in selling, how to sell association membership, how to sell Certified Heating and how to sell radiator heating to builders.

Social features of the convention included trips to places of interest in the vicinity, a dinner-dance and a trip to Churchill Downs for the races.

The survey of the heating industry, as revealed by questionnaires to the association members, compiled and presented by Secretary Joseph C. Fitts, contained a picture of the contractors' side of the industry. Not only is the anticipated new building volume less than 1930 but the trend of overhead ratios seems upward and the trend of net profits downward. The survey brings out well the importance of



Courtesy U. S. Bureau of Standards

Test duct with inlet ring removed and a 9 ft. 11 in. fan in place, used in a project carried out by the Government to measure propeller fan characteristics.

the replacement market as a means of offsetting the shrinkage of volume during the current year. The survey also affords a valuable comparison with like information collected a year ago.

Work of the association's committee on standards is always of interest to engineers. The report of the committee referred to an analysis now being made of the steam consumption of various buildings to learn more about the effects of wind on the consumption; to efforts being made to secure more reliable data for use in proportioning hot-water piping, and to arrangements completed with New York University to secure data on the effects of varying weather conditions on the steam consumption of an isolated building.

Other officers elected in addition to Mr. Spitzley as president were: Robert D. Williams, New York, vice-president; J. Lawrence De Neille, St. Louis, treasurer. New directors are: M. J. Schagmard, Louisville; Merwin Porter, Minneapolis. Walter Klie, John S. Jung, and Robert D. Williams were re-elected to the board.

North Tonawanda District Steam Rate to be $1.35 Per Thousand Pounds

The rate for district steam in the proposed district heating system for North Tonawanda, New York, will be a maximum of $1.35 per thousand pounds, with a minimum rate of $1 per thousand pounds. It was incorrectly stated in these columns recently* that the rate would be 50 cents per thousand pounds.

Program of A.S.H.V.E. Summer Meeting

Members of the American Society of Heating and Ventilating Engineers will meet at Swampscott, Mass., twelve miles north of Boston, for the semi-annual meeting of the organization, June 22-25, 1931. The papers at the technical sessions will be as follows:

JUNE 23

"Flow of Steam through Orifices into Radiators," by S. S. Sanford and C. B. Sprenger.

"Friction Heads in One-Inch Standard Cast Iron Tees," by F. E. Giesecke and W. H. Badgett.

"Revised Pipe and Orifice Sizes for Small Gravity Circulation Hot Water Heating Systems," by E. G. Smith.

"Using Gas Vapor Mixtures for Heating Purposes," by C. A. Dunham.

JUNE 24

"Essential Elements for Determining Heating Plant Requirements," by F. B. Rowley.

"Performance Characteristics of Cast Iron and Non-Ferrous Radiators," by A. C. Willard.

"Study of Performance Characteristics of Oil Burners and Low Pressure Heating Boilers," by L. E. Seeley and E. J. Tavanlar.

"Heating Effect," by R. N. Trane and C. J. Scanlon.

JUNE 25

"Heat and Moisture Losses from the Bodies of Men Working and Their Application to Air Conditioning Problems," by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant.

"Infiltration through Double Hung Wood Windows," by G. L. Larson, D. W. Nelson and R. W. Kubasta.

"The Measurement of the Flow of Air through Registers and Grilles," by L. E. Davies.

Registration will open at 9:30 a. m. Monday, June 22. Meetings of the council, research, nominating and Guide publication committees will be held in the afternoon.

Reports of the committees on increase of membership, Guide publication and testing and rating unit ventilators will be presented Tuesday, June 23. On Wednesday, June 24, the report of the committee on rating and testing concealed gravity type radiation will be given.

Reports of the committees on ventilation standards, research, and that of the technical advisory committee will be presented Thursday, June 25.

Air Conditioning for Clubs

At a meeting and dinner of The Club Managers Association of America, at the Detroit Yacht Club, April 6, the problem of refrigeration in clubs, restaurants and hotels was discussed. Not only was the question of food preservation dealt with, but also the cooling of the dining rooms of these institutions was discussed by W. D. McElhinny of the Copeland Company.

News of the Month

Financial Writer Lauds Idea of Air Conditioned Trains

Announcement was made during May by the Baltimore & Ohio Railroad of the first train to be completely air conditioned. The system will clean the air and maintain correct humidity and temperature in every car. The train which has the distinction of being thus air conditioned is "The Columbian," which operates daily between New York, Philadelphia, Baltimore and Washington. There is no extra fare.

Commenting on this idea in the New York *World-Telegram*, May 18, Ralph Hendershot, financial editor, stated that he was convinced that the decision of the Baltimore & Ohio to provide such air conditioning would be far more productive of results than a reduction of rates to increase transportation. In Mr. Hendershot's opinion, as a nation we demand the best for our money, rather than the most, even in times of depression.

Zink Condemns Questionable Welding Practices

John H. Zink, who spoke before the annual meeting of the American Welding Society, April 23, on welding in the heating and piping industry, made a strong appeal for the cooperation of all interested parties to the end that the use of pipe welding may develop along sound lines. He was optimistic of the future and predicted that even small residence heating plants would use welding as a preferred method of installation when contemplated piping material improvements are accomplished. The address was notable also because of the strong position taken by the speaker in insisting that it is essential that more attention be paid to educating the contractor himself

* HEATING AND VENTILATING, April, 1931, p. 104.

on welding and welding practices rather than concentrating educational effort on mechanics.

Mr. Zink also assailed the practice of selling welding equipment to irresponsible contractors by misrepresenting the facts, and felt that more would ultimately be accomplished by working with contractors able and willing to secure real quality work. He pointed out that the mere fact that a contractor owns welding equipment does not necessarily mean that his organization is equipped to secure high-grade results, and also questioned the wisdom of encouraging building owners to buy their own equipment and make their own installations of piping presumably to save the contractor's profit.

Attention was called to the increasing prevalence of inferior, unbranded and unknown specification welding rod. He regarded this as becoming so serious that control of the rod should be exercised. Moreover, he felt that unless those interested in the quality of welding voluntarily undertook the responsibility for inspection and certification compulsory measures would soon be taken by public authority.

Short Course in Gas Engineering to Be Held at University of Illinois

A short course in industrial gas engineering will be held at the University of Illinois beginning June 15 and lasting throughout the week. The course will be under the direction of the University of Illinois, with Prof. D. B. Keyes presiding, and under the auspices of the Illinois Gas Association. This is believed to be the most intensive short course on the subject of industrial gas ever held. Address A. D. Frydendal of The Peoples Gas Light and Coke Company, Chicago, for further information.

Air Conditioning Discussed at A.S.R.E. Meeting

At the summer meeting of the American Society of Refrigerating Engineers, held at Kansas City, May 6-8, Maurice Olchoff summarized the results from recent studies regarding the heat losses from the human body and the effect of temperature, humidity and air motion on human comfort. Tabulated data were given to show the relations between the heat loss from the human body by evaporation, radiation and convection, and the dry bulb temperature; and the desirable indoor temperature corresponding to outside temperatures. Of the several air conditioning systems that provide means for controlling both the temperature and moisture content of the air introduced, the author illustrated by diagram two methods of operation and worked out the refrigerating requirements. One system uses recirculated air for reheating, and the other uses steam to reheat the air to proper conditon. Brief comment followed on the three principal refrigerants in air conditioning work, ammonia, carbon dioxide and carrene, and on the requirements of the equipment used.

Discussion of the paper indicated that comfort cooling by ice in the home might readily compete with air conditioning, owing to the less expensive installation required.

COMING EVENTS

June 2-5, 1931. Annual Convention of the National District Heating Association in Boston. Headquarters at the Hotel Statler.

June 8-11, 1931. Annual Convention and Informashow of the National Association of Purchasing Agents in Toronto, Canada. Headquarters at the Royal York Hotel.

June 22-25, 1931. Forty-Ninth Annual Convention Exposition of the National Association of Master Plumbers, to be held in Milwaukee, Wis. Headquarters at the Milwaukee Auditorium.

June 23-26, 1931. Summer Meeting, American Society of Heating and Ventilating Engineers, at Swampscott, Mass.

June 30-July 3, 1931. Smoke Abatement Convention and Exhibit of the National Smoke Prevention Association, Grand Rapids, Mich. Headquarters at the Hotel Pantlind. Secretary, G. M. Watson, Hotel Pantlind, Grand Rapids, Mich.

July 13-17, 1931. National Association of Building Owners and Managers. Headquarters at the Olympic Hotel, Seattle, Wash.

September 7-11, 1931. Annual Convention and Mechanical Exposition of the National Association of Power Engineers. Headquarters at the Convention Hall, Kansas City, Mo. Secretary, Fred W. Raven, 417 S. Dearborn St., Chicago.

September 14-17, 1931. Sixtieth Annual Convention of the American Public Health Association, at Montreal, Canada.

October 12-13, 1931. Thirteenth Annual Convention and Exhibition of the American Gas Association, Municipal Auditorium, Atlantic City, N. J.

November 30-December 5, 1931. First National Exposition of Mechanical Handling at the Grand Central Palace, New York.

January 25-28, 1932. Joint Annual Meeting of the American Society of Heating and Ventilating Engineers, and the American Society of Refrigerating Engineers, at Cleveland, Ohio.

January 25-28, 1932. Second International Heating and Ventilating Exposition, at Cleveland, Ohio.

Anthracite Club Formed in Philadelphia

At an enthusiastic meeting held at the Hotel Pennsylvania, Philadelphia, May 11, the Anthracite Club of Philadelphia was formed. This is the fifth club thus organized; clubs previously having been formed in New York, Providence, R. I., Rochester, N. Y. and Malden, Mass.

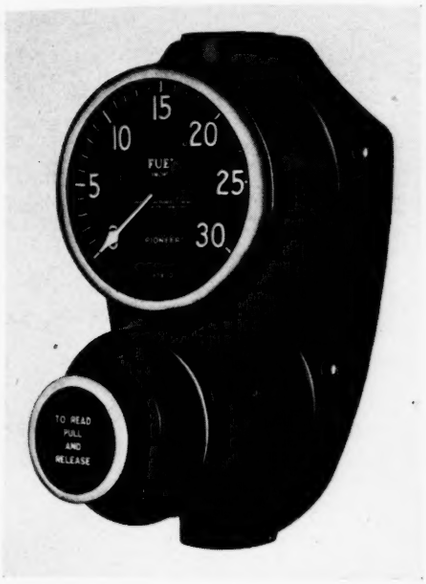
Prominent in the organization of the new club were Lane W. Hildreth, Philadelphia manager of the Anthracite Coal Service; E. P. Bliss, Jr. of the Thermatic Combustion Corporation and Arnold Michelson, resident vice-president of Minneapolis-Honeywell Regulator Company. More than twenty-five men attended, representing practically every industry which comes into contact with the consumer in the use of anthracite. Mr. Hildreth acted as temporary chairman.

Oscar F. Ostby, president and prime mover in the organization of the Anthracite Club of New York, told of the organization and progress of the club in New York. Louis B. Gallison, assistant to the president of the Philadelphia and Reading Coal and Iron Corporation, spoke of the work of the Rochester Club in interesting architects in improving the location of the coal bin.

New Equipment

Pioneer Oil Level Gauge

Production of an oil level gauge for domestic and commercial use was announced recently by the Pioneer Instrument Co., Division of the Bendix Aviation Corp., 754 Lexington Ave., Brooklyn, N. Y.



Oil Level Gauge.

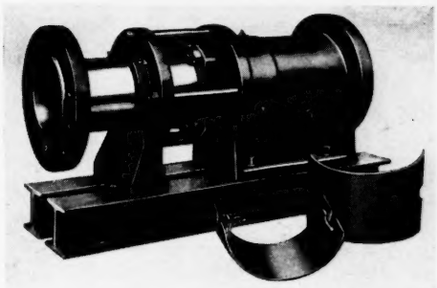
A hydrostatic cell placed at the bottom of the oil tank contains air which is compressed by the weight of the liquid above it. This air pressure is transmitted through a copper tube from the cell to the gauge, the latter being a sensitive pressure indicator, calibrated to translate the air pressure into quantity of fuel oil in the tank. Due to the temperature changes and the consequent expansion and contraction of the air, means for correcting the error arising from the lost air must be provided. For this purpose a plunger pump is incorporated into the case of the gauge. Whenever it is desired to know the oil level with accuracy, it is only necessary to pull out the pump knob once and release it. On the return stroke the pump automatically introduces the necessary amount of air to balance the system.

The gauge is made in standard ranges of 30 in., and 70 in. Each instrument is supplied with 30 feet of copper tubing. The gauge case is of black molded bakelite with a chromium bezel.

Murfco Heavy Duty Expansion Joint

The Murfco heavy duty expansion joint has been announced by the Murphy Machine Co., Witherspoon Bldg., Philadelphia, Pa. The feature of the joint is that it has a permanently fixed extension guide which is rigidly attached to the body of the joint proper. The manufacturer claims that this absolutely precludes any chance of misalignment and consequently preserves the packing in its concentric position with the sleeve. This not only eliminates leakage but makes the repacking of the joint extremely simple.

Another feature is found in the lubricating system. Alemite fittings lead a charge of zinc oxide lubricating compound under pressure through a metal distributing ring, forming the lubricant into a thin film between the packing and sliding sleeve. Hence, the packing is impregnated and preserved in a soft pliable and resilient condition. The joint in type A and type B is made in sizes ranging from 2 in. to 36 in. in diameter.



Murfco Type A Expansion Joint.

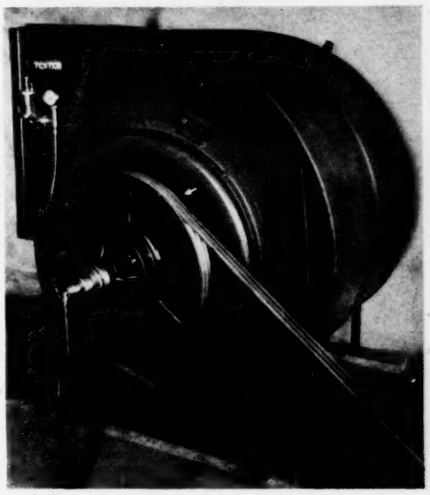
Schutte & Koerting Spray Nozzles

Shutte & Koerting Co., 12th and Thompson Sts., Philadelphia, Pa., announces a new line of spray nozzles for water, oil and other liquids. The standard nozzle, as made by this company, is provided with a fine pitch spiral and produces a wide angle 80° hollow cone spray, uniformly atomized. This type is recommended for installation where liquids in quantities not over 3 gal. per min. are to be sprayed as a fine mist. For this service the smaller nozzles should not be operated at a pressure less than 60 lb. and the larger ones not less than 40 lb. At 50-lb. pressure the ½ mm. size has a capacity of 4 gal. per hr., while the largest size, 6½ mm., at this pressure has a capacity of 133 gal. per hr. There are 16 sizes in all in the standard line.

Horton Variable-Speed Fan Drives

A variable speed fan drive, especially designed to meet the demands for quiet in theaters showing sound pictures, is being marketed by the Horton Mfg. Co., 3016 University Ave., S. E., Minneapolis, Minn. The drive is a multi-belt type, hydraulically controlled. Control may be manual or hydraulic, as desired, or may be locked and converted into a constant speed drive. The purpose of the unit is to vary the speed to meet atmospheric conditions, so that at times when the fan is needed only to keep the air moving so as to reduce dead air pockets, which do not transmit sound, the power consumption will be reduced.

Speed changes can be instantly effected by operating the distantly located control which forces fluid into or withdraws it from the fluid ram on the hub through which pressure is applied to or diverted from the driving connections. The blower speed increases or decreases in



Horton Variable Speed Fan Drive.

proportion to the amount of pressure exerted. The drive is obtained in numerous sizes and capacities.

Draft Stabilizer

A draft stabilizer has been brought out by the Silent Automatic Corp., Detroit, Mich. The purpose of the device is to control automatically the intensity of the natural draft, especially when starting the oil burner.

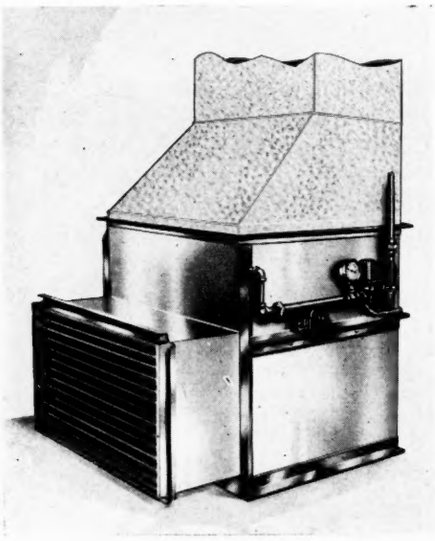
The draft stabilizer is attached to the vertical or horizontal smoke pipes of any domestic type of heater. It has a mechanically counterbalanced damper that swings free on a lever arm in the smoke pipe. It can be adjusted to a fine setting for the most efficient flame and assure its stability. When set for the most efficient oil burner operating conditions it adjusts itself to compensate for varying draft conditions.

The manufacturer claims that it reduces excess air, lessens stack loss and betters the economy of operation through maintaining stability.

Am-Pe-Co Air Washer-Blower

American Machine Products Co., Marshalltown, Iowa, has placed on the market the Am-Pe-Co air washer-blower, designed for use in any ventilating or warm-air heating system.

Both the washer and blower are built into a single housing made of heavy gauge galvanized iron. Nozzles at either inlet opening produce a fan-shaped spray which is mixed with the air in the scroll. A deflector in the outlet opening prevents the water from being carried through and waste water is carried away by a drain in the floor of the unit. The interior is coated with red lead and waterproof enamel.



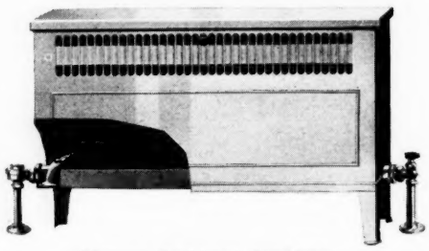
Air Washer and Blower for Warm Air Systems.

Water supply is controlled by a solenoid valve which automatically turns on the spray when the blower is operating and closes when the blower stops. A pressure gauge is furnished to indicate the amount of water pressure and also a strainer for preventing dirt from entering the valve and nozzles.

The manufacturer states that in residence work requiring 1600 c.f.m., the static pressure was not greater than 0.08 in. The units are made in 13 sizes with capacities ranging from 1650 c.f.m. to 9000 c.f.m.

Young Cabinet Radiators

A line of copper cabinet radiators is being marketed by the Young Radiator Co., Racine, Wis. Heavy copper fins are crimped vertically for strength and are bonded metallically to the copper tubes. The unit is coated with a special alloy by immersion process. The tubes are high-temperature brazed to the header. The cabinets are made in heights of 20 in., 23 in., 26 in., 32 in. and 36 in., in five widths ranging from 3½ in. to 10½ in. and capacities ranging from 10 sq. ft. to 133 sq. ft. of equivalent radiation.

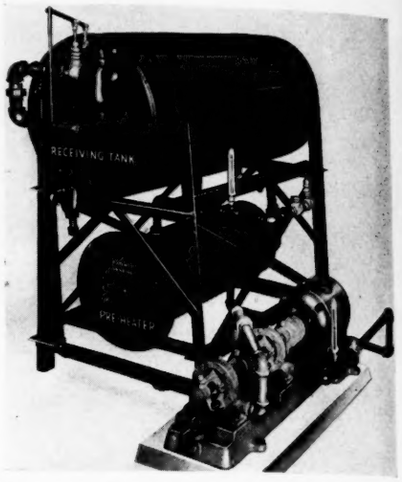


Young Cabinet Radiator.

The radiators are also available in a line of bathroom cabinets. These radiators are made in heights of 8 in., 10 in. and 12 in. in two widths with capacities ranging from 6.2 sq. ft. to 25.2 sq. ft. of equivalent radiation.

Monarch Boiler Feed Water Pre-Heater

Announcement has been made by the Monarch Sales & Engineering Co., 2010 Locust Blvd., St. Louis, Mo., of the Monarch boiler feed water pre-heater. This device is to be installed between the pumping unit and the boiler. Condensate will pass through the pre-heater first, then enter the receiver at the bottom so that the condensate stored in the receiver will absorb the vapor. From the receiver, the hot condensate passes to the pumping unit and into the pre-heater in which it flows around the tubes which are heated by the very hot condensate passing through the tubes. After the water is so heated by the condensate, it is pumped into the boiler.

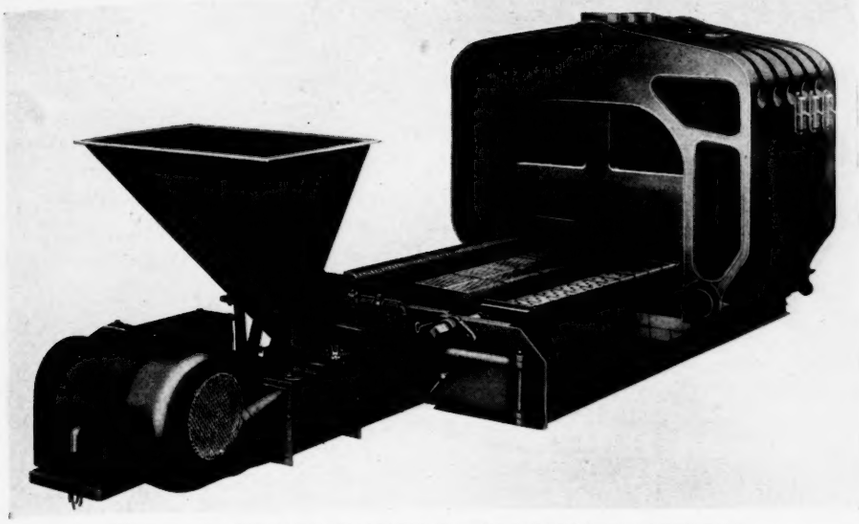


Monarch Boiler Feedwater Pre-Heater.

The Electric Janitor

Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., has announced The Electric Janitor, an all-electric motor-driven temperature regulator for coal-fired home-heating plants. The device is manufactured by the Time-O-Stat Controls Division of the company at Elkhart, Ind. The apparatus is designed for the moderate price field and will retail at $49, plus cost of installation, with limiting device for slightly more. The price to the trade is $24.50, packed fully equipped, including wiring, transformer, and all accessories.

Five features are embodied in The Electric Janitor. These include low installation cost through operation on low voltage through trans-



Stoker Equipped Boiler Showing Front Sections Removed.

former furnished as part of the equipment, full electric operation with special induction type motor; basement switch which closes check and opens draft for firing without disturbing position of thermostat, and a complete line of limit controls for hot water, vapor, steam or warm air.

Capitol Stoker-Equipped Boilers

The K-Series stoker equipped line of cast iron boilers has been placed on the market by United States Radiator Corp., Detroit, Mich. There are six sizes available, with capacities ranging from 3800 to 5800 sq. ft. of steam radiation, guaranteed ratings.

The boiler is of the low water line type having a large combustion space behind a water-backed bridge-wall. From this chamber the gases pass to the front of the boiler through flues on either side of the firebox, returning through an upper gallery of side flues to the smoke-hood. The distance from crown sheet to bottom of water leg is 42 in. The boiler rests upon a 4 in. channel iron base, bringing the water-backed walls of the firebox to a point only 4 in. from the floor and 9 in. below the dump grate level of the stoker.

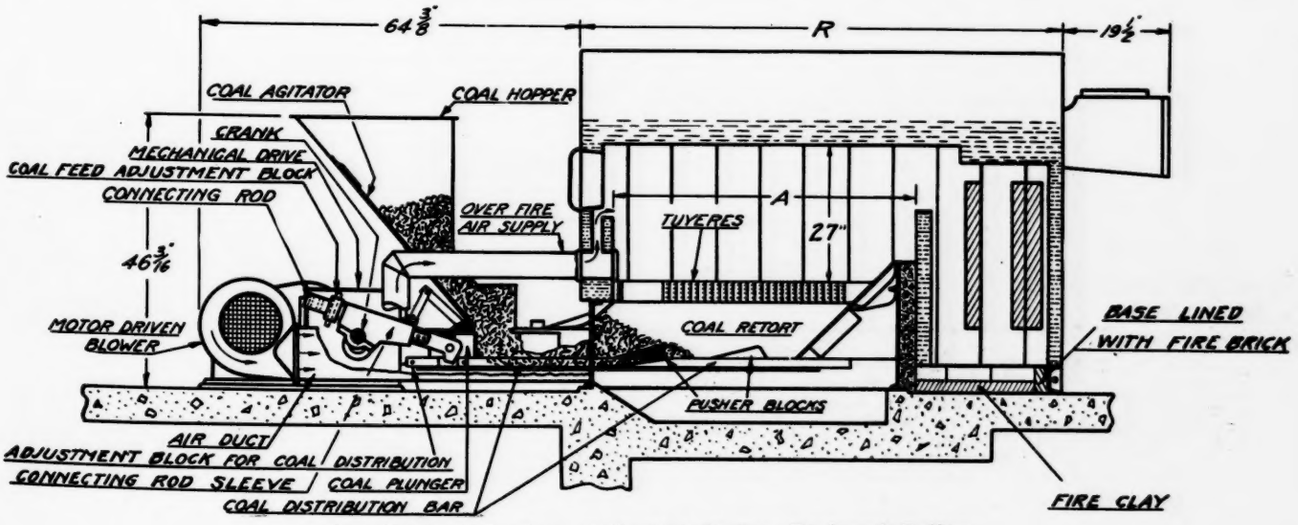
A coal agitator prevents any possibility of coal arching in the hopper and not feeding into the firebox. Coal fed from the hopper falls in front of a plunger which pushes a charge of coal into the retort.

As coal moves into the retort it is transferred to pusher blocks, which are so shaped and spaced as to distribute the fuel evenly in the retort. As the coal moves upward in the retort, pushed by fresh coal fed from underneath, it covers the tuyeres and gradually moves toward dump grate. By this method the fresh coal is always fed from underneath the burning zone. The gases distilled from the fresh fuel must pass through incandescent coals before leaving the fuel bed. As the coal continues to burn it moves toward the dump grate, finally collecting on the latter.

From the dump grate the ash is periodically dumped into the ash storage space below, whence it can be removed at the operator's convenience.

To reduce the rate of coal feeding, the coal feed adjustment block is moved nearer the end of the connecting rod by lifting a pin which holds it in place. When this is done the sleeve which operates the connecting rod is allowed to slide a certain distance on the connecting rod before it reaches the adjustment block. This shortens the return stroke of the plunger so that it does not entirely uncover the opening from the hopper. Therefore, with each forward stroke of the plunger a smaller charge of coal is pushed into the boiler. This adjustment can be made while the stoker is in operation.

At no additional cost to the heating contractor, the stoker is installed in the boiler by erectors provided by the manufacturer and supervised by a competent engineer. The stoker is adjusted to the fuel available, and the operator instructed in its operation.



Longitudinal Section of Capitol Stoker Equipped Boiler.

New Equipment

Fitzgibbons Announces New Construction Feature

Fitzgibbons Boiler Co., New York, recently announced the development of a new type of construction adaptable to its several lines of steel heating boilers.

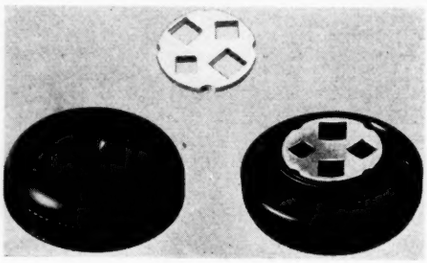
To quote the manufacturers, Fitzgibbons construction consists of having all seams which are subjected to major strains riveted, all seams in which water-tightness is the essential requirement, and which are additionally supported, are welded.

The new design is a combination of the strength of riveted joints for certain structural conditions and the compact, shock-proof and leak-proof desirability of welded joints. Modern mechanical firing of boilers has created new problems in the furnace design of firebox boilers which are met by the new construction. The single unit of welded plates composing the firebox of the Fitzgibbons boiler is shock-proofed against the high temperature and rapid expansional and contractional changes to which it is subjected by oil, gas or stoker firing. The new construction is available in all of the lines of steel heating boilers manufactured by the company, and meets the requirements of the A.S.M.E. Code as a minimum and also the state and municipal codes.

Hygienic Warm-Air Heating System

A domestic air conditioning system has been designed by H. M. Nobis, 1827 Stanwood Road, East Cleveland, Ohio. The system, known as the Hygienic, is composed essentially of a gas, coal or oil-fired steam boiler, which supplies steam to radiators in the kitchen or other rooms where odors exist, and which also supplies steam to a fin-tube radiator surface set in a chamber through which air can be passed and delivered to the rooms, a turbine-driven fan, and a wet air filter.

The accompanying illustration shows the general arrangement of the unit. Advantages claimed for the system are that the air is not burned, so that the dust content is not broken down, the filters are self cleaning, semi-automatic humidity control is supplied, there are no fuel restrictions, and if summer cooling is desired this can be accomplished by cooling the water in the make-up tank.



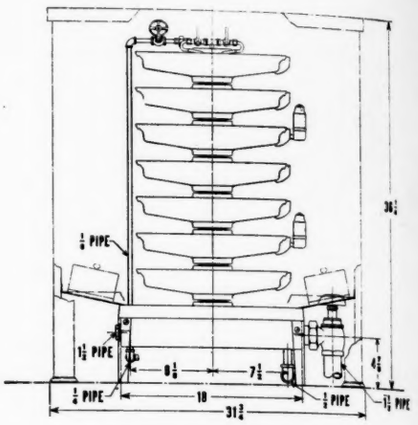
Valve Handle.

Four-In-One Valve Handle

Diemolding Corp., Canastota, N. Y., announces a valve handle so made that it can be used in connection with four different size valve stems. A removable plate on the back of the handle is inserted in a keyed opening in an eccentric position, so that the opening of the size desired is on center.

The handle is molded of bakelite to provide a cool handle. The black finish has a deep polish, and the handle is knurled to provide a positive grip. The attaching screw is well countersunk to avoid a hot spot.

Made in two sizes, 2¼ in. and 3¼ in. in diameter, the two sizes can accommodate eight different sizes of stems.



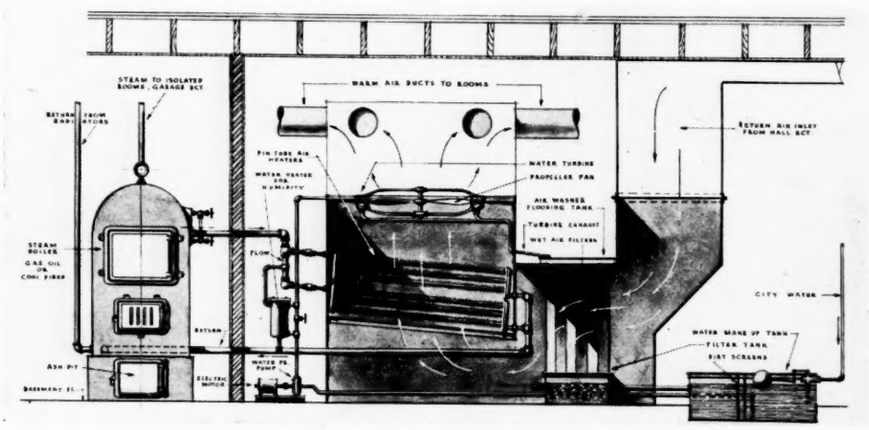
Cascade Humidifier.

Ideal Cascade Humidifier

American Radiator Co., 40 West 40th St., New York, placed on the market recently the Ideal Cascade humidifier, designed for maintaining the proper degree of moisture in homes. The unit is composed of individual sections connected by screw nipples, the bottom section so designed that excess water flows to waste through a tapping. Tappings are furnished on both ends, so that in the case of a one-pipe steam heating system either end can be used as a steam inlet or for trap connection in the case of a two-pipe system. A special tapping is also provided to which the water supply pipe is connected.

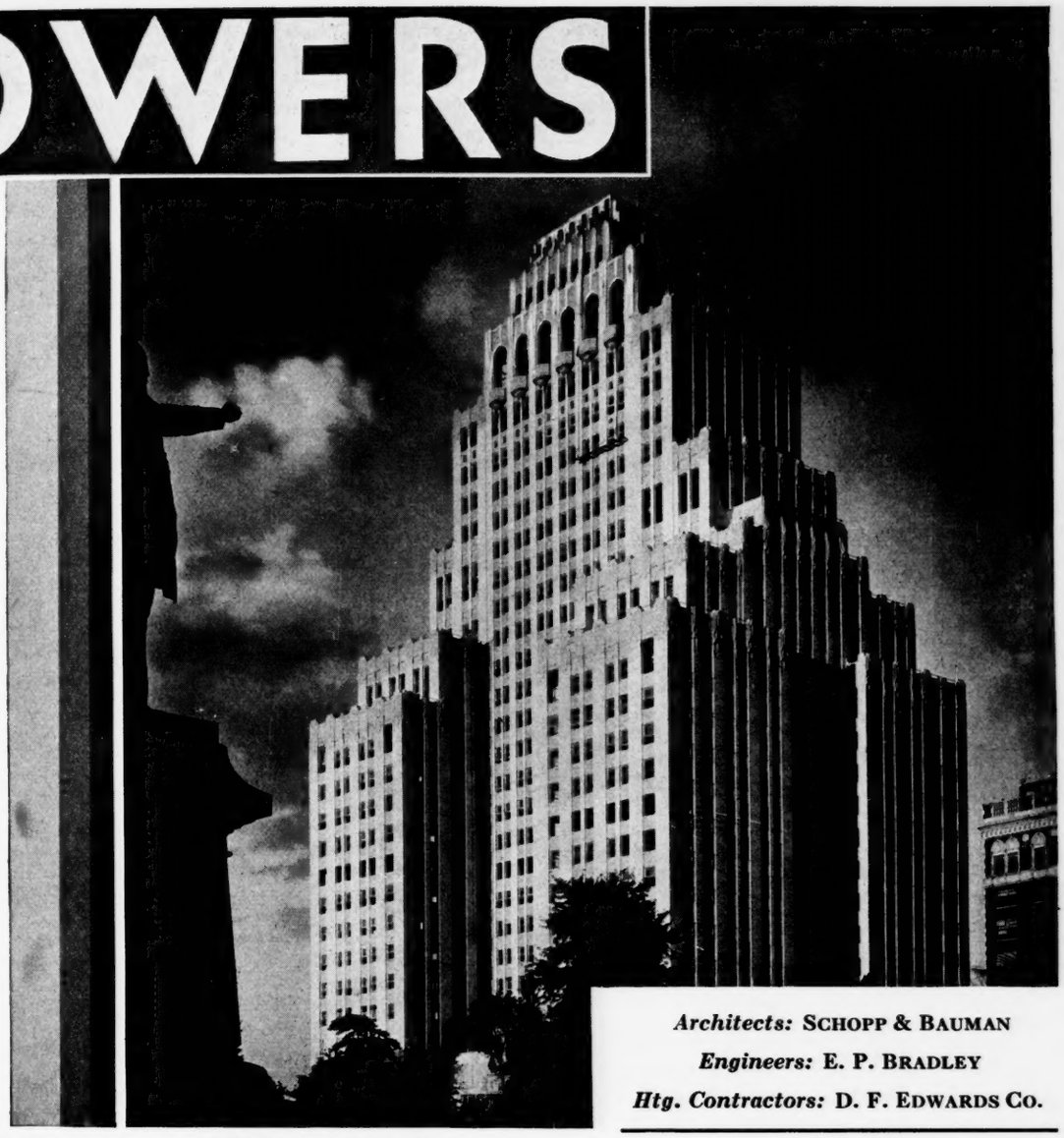
The top surfaces of the other sections are flat and pitched slightly toward the nipple. City water is supplied through a pressure reducing valve to the top section, and after flowing it slowly trickles over the ends to the sections below. When steam is admitted to the humidifier, the water flowing from section to section absorbs heat from the steam and evaporates the water.

Steam consumption of a 7-section humidifier is equivalent to 80 sq. ft. of steam radiator. The heat output corresponds to that of a 15 sq. ft. radiator and will evaporate 12 lb. of water per hr. The unit cannot be used on a water heating system.



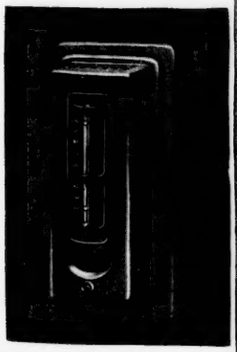
Hygienic Air Conditioning System for Homes.

POWERS



Architects: SCHOPP & BAUMAN
Engineers: E. P. BRADLEY
Htg. Contractors: D. F. EDWARDS CO.

Park Plaza Hotel St. Louis Mo.



Powers Thermostats Are Better

Because—they need no annual adjustments or overhauling and often give 15 to 20 years of accurate control without repairs of any kind.

Here's another prominent building in St. Louis equipped with the Powers System of Automatic Temperature Control.

In addition to controlling temperature of direct and indirect radiation Powers Regulation is also used on seven hot water heaters used in this building.

Wherever QUALITY is the main consideration you will invariably find Powers Control used. Because:

◄1► It often gives 15 to 20 years of Accurate and Dependable control without repairs of any kind.

◄2► Greater Steam Economy due to the fact that thermostats do not get out of adjustment and permit overheating.

◄3► Graduated Control, because of its greater accuracy, provides maximum comfort for occupants of rooms.

◄4► A minimum of Service Calls and the trouble and annoyance connected with them.

THE POWERS REGULATOR CO.

40 years of specialization in automatic heat control

2728 Greenview Ave. CHICAGO **231 E. 46th Street NEW YORK**

Offices in 41 other cities

TORONTO: 106 Lombard Street

Degree Days and Unit Fuel Consumption in Typical Cities

April, 1931

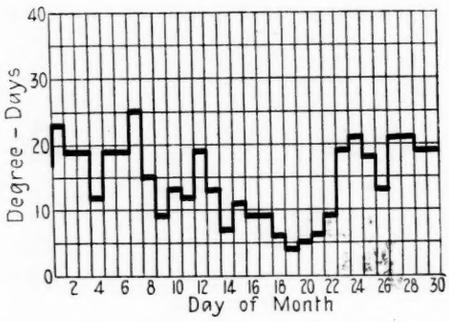
UNIT fuel consumption figures given below must be corrected for efficiency, heat content of fuel other than that listed below, for radiation emitting other than 240 B.t.u. per hr., and for radiation calculated on a basis of other than zero outside to 70° inside.

Coal is assumed as having a heat content of 12,000 B.t.u. per lb., gas, 1000 B.t.u. per cu. ft. and oil 140,000 B.t.u. per gal. To correct for other heating values, multiply the fuel consumption listed under the charts by the standard heat content just listed, and divide by the heat content of the fuel actually being used in the installation being calculated.

For radiation installed for any other outside temperatures than zero, multiply the fuel consumption given under the charts by 70°, divided by the quantity (70 minus the outside temperature used).

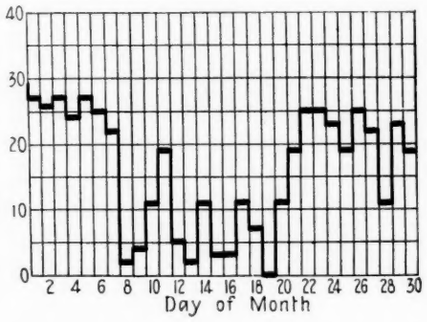
To correct for efficiency, divide the fuel consumption by the efficiency of the heating installation.

For water radiation, multiply the fuel consumption which is given for steam radiation by 5/8.



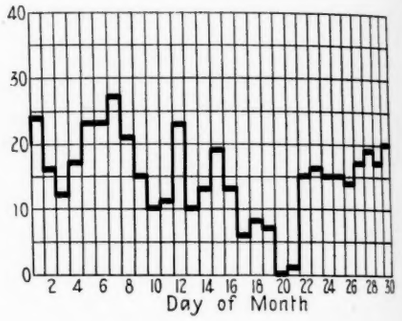
New York, April, 1931

Degree Days 434—to Date, 4877
Lb. of Coal per Sq. Ft. of Radiation for this Month, 3.47.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.298.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 41.66.
(See Footnote)



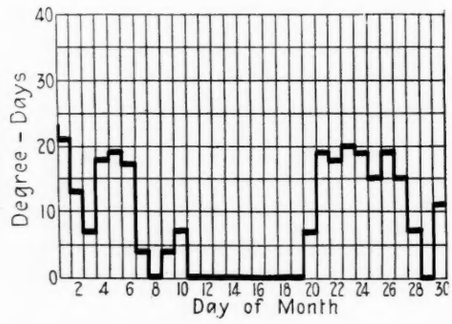
Chicago, April, 1931

Degree Days 473—to Date, 5536
Lb. of Coal per Sq. Ft. of Radiation for this Month, 3.78.
Gal. of Oil per Sq. Ft. of Radiation for this Month,, 0.324.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 45.41.
(See Footnote)



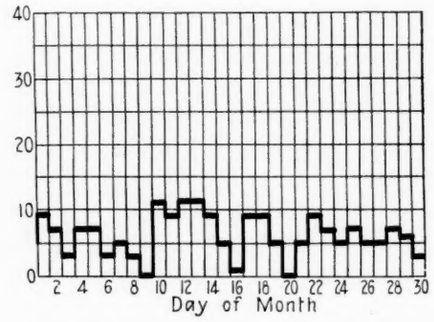
Boston, April, 1931

Degree Days 447—To date, 5255
Lb. of Coal per Sq. Ft. of Radiation for this Month, 3.58.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.307.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 42.91.
(See Footnote)



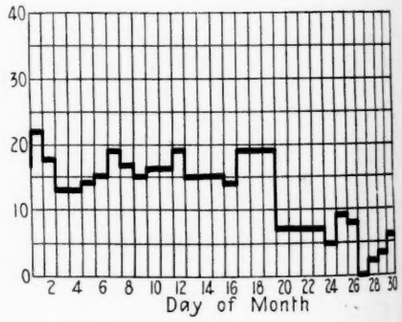
St. Louis, April, 1931

Degree Days 270—to Date, 4257
Lb. of Coal per Sq. Ft. of Radiation for this Month, 2.16.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.185.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 25.92.
(See Footnote)



San Francisco, April, 1931

Degree Days 183—to Date, 1796
Lb. of Coal per Sq. Ft. of Radiation for this Month, 1.46.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.125.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 17.57.
(See Footnote)



Seattle, April, 1931

Degree Days 374—to Date, 3989
Lb. of Coal per Sq. Ft. of Radiation for this Month, 2.99.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.256.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 35.90.
(See Footnote)

Fuel consumption figures must be corrected for local conditions as explained above.

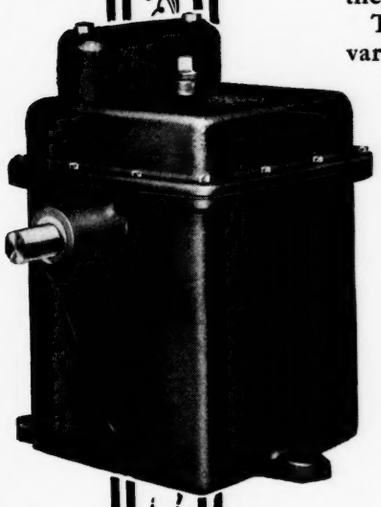
(Continued on Page 110)

WHY BETTER

Reason No. 8

The Barcol Reversing Damper Controller

BARCOL



ON indirect heating systems it is often desirable to "float" the dampers in order to keep the duct or room temperature at a given level.

This can best be accomplished by the use of a *reversing* motor-operator. The Barber-Colman Reversing Damper Controller is equipped with a reversible motor, by which the direction of rotation of the damper-lever shaft may be changed at any time, should the thermostat call for more or less heat.

The contacts established by the thermostat tongue, resulting from variations in the duct or room temperature, cause the motor of the damper controller to rotate in one direction or the other. When the tongue touches one contact the motor turns in one direction; when the tongue touches the other contact the motor is reversed. Then, when the thermostat tongue is not touching either contact, the motor does not operate, and the damper remains in whatever intermediate position it assumed when the movement was interrupted by the thermostat, thus giving a true "floating" action. The temperature change required to cause this reversal of the motor-operator, and the consequent movement of the damper itself, is a variation of one degree, plus or minus, from the temperature for which the thermostat is set.

Like the Barcol Positive Damper Controller the Reversing Type is immersed in oil and sealed in the case. The Controller itself may be mounted in any position, and may be controlled from any of the various types of Barcol Thermostats or from a manually operated switch.

MANUFACTURED BY

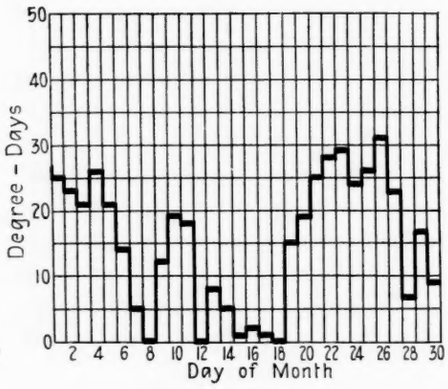
BARBER-COLMAN COMPANY

ROCKFORD, ILLINOIS

Degree Days and Unit Fuel Consumption in Typical Cities

April, 1931

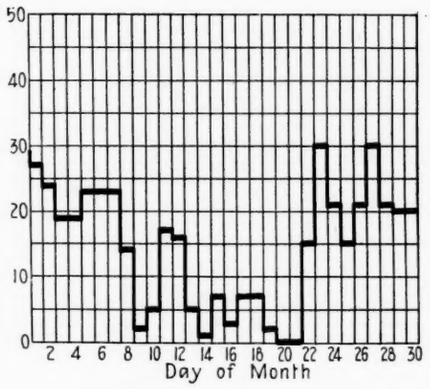
(Continued from Page 108)



Minneapolis, April, 1931

Degree Days 454—to Date 6474
Lb. of Coal per Sq. Ft. of Radiation for this Month, 3.63.
Gal. of Oil per Sq. Ft. of Radiation for this Bonth, 0.311.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 43.58.

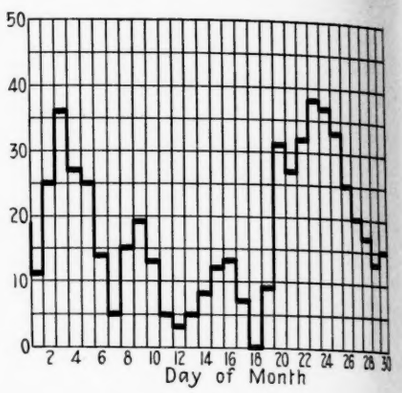
(See Footnote, Page 108)



Pittsburgh, April, 1931

Degree Days 437—to Date, 5266
Lb. of Coal per Sq. Ft. of Radiation for this Month, 3.50.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.300.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 41.95.

(See Footnote, Page 108)



Denver, April, 1931

Degree Days 526—to Date, 5350
Lb. of Coal per Sq. Ft. of Radiation for this Month, 4.21.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.361.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 50.50.

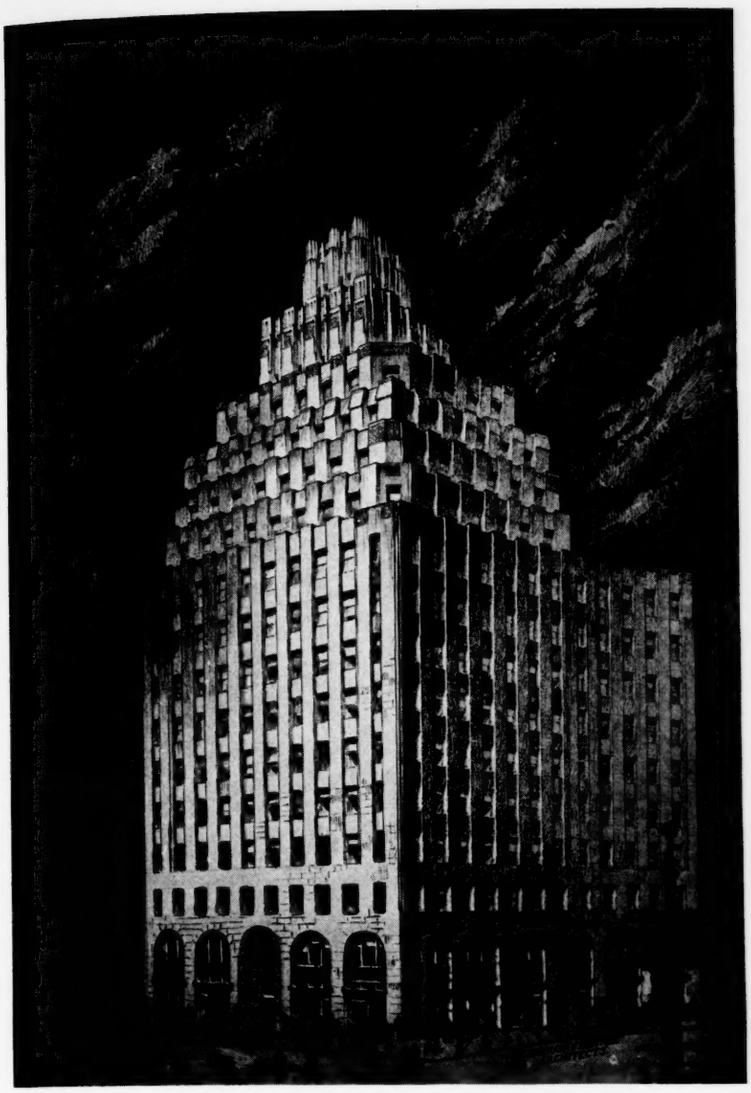
(See Footnote, Page 108)

	Los Angeles	Baltimore	Philadelphia	New Orleans	Atlanta	Cleveland	Cincinnati	Detroit
Degree Days	36	337	360	53	185	539	356	480
Degree Days to Date	658	4252	4404	1435	3360	5520	4846	6088
Lb. of Coal per Sq. Ft. of Radiation for April, 1931	0.29	2.70	2.88	0.42	1.48	4.31	2.85	3.84
Gal. of Oil per Sq. Ft. of Radiation for April, 1931	0.025	0.231	0.247	0.036	0.127	0.370	0.244	0.329
Cu. Ft. of Gas per Sq. Ft. of Radiation for April, 1931	3.46	32.35	34.56	5.09	17.76	51.74	34.18	46.08

(See Footnote, Page 108)

	Buffalo	Birmingham	Indianapolis	Memphis	Des Moines	Kansas City	Louisville	Galveston
Degree Days	601	146	374	161	387	316	291	58
Degree Days to Date	6178	2880	5104	3194	5416	4384	4411	1400
Lb. of Coal per Sq. Ft. of Radiation for April, 1931	4.81	1.17	3	1.29	3.10	2.53	2.33	.46
Gal. of Oil per Sq. Ft. of Radiation for April, 1931	0.412	0.100	0.256	0.110	0.265	0.217	0.200	0.040
Cu. Ft. of Gas per Sq. Ft. of Radiation for April, 1931	57.70	14.02	35.90	15.46	37.15	30.34	27.94	5.57

(See Footnote, Page 108)



CIRCLE TOWER, INDIANAPOLIS

Architect: Rubush and Hunter, Indianapolis, *Specification Engineer:* S. E. Fenstermaker, Indianapolis, *General Contractor:* Wm. T. Jungclaus Co., Indianapolis, *Plumbing and Heating Contractor:* Callon Bros., Indianapolis

the aristocrat

...of Indianapolis

Circle Tower, heralded as the finest office building in Indianapolis, is a worthy addition to the downtown development of this progressive city. Modern to the minute—excellently located—it brings new standards in luxury and convenience to the Hoosier Capital.

All specifications for materials and equipment were scrutinized in a most thoroughgoing way with a view to intrinsic worth and also to what might increase the prestige of a distinguished building.

In keeping with this principle, NATIONAL Pipe was chosen for the major pipe tonnage—one more testimony to the standing of—

America's Standard Wrought Pipe

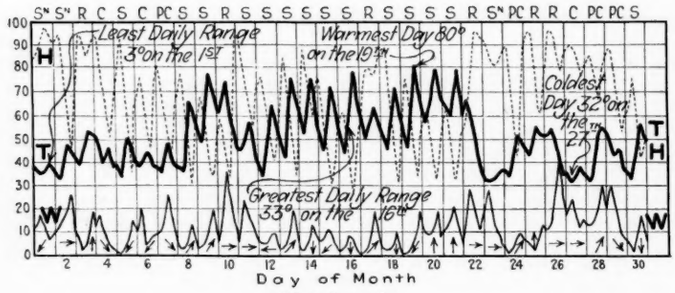
NATIONAL TUBE COMPANY · Pittsburgh, Pa.

Subsidiary of United States Steel Corporation

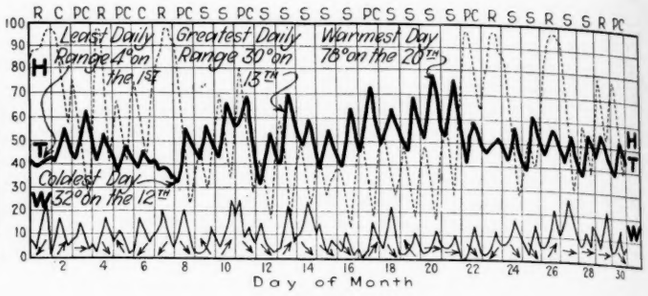
NATIONAL PIPE

The Weather

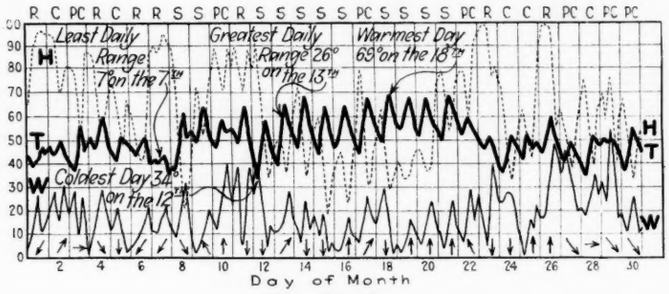
April, 1931


Least Daily Range 3° on the 1st
Warmest Day 80° on the 19th
Coldest Day 32° on the 27th
Greatest Daily Range 33° on the 16th
Day of Month

Pittsburgh

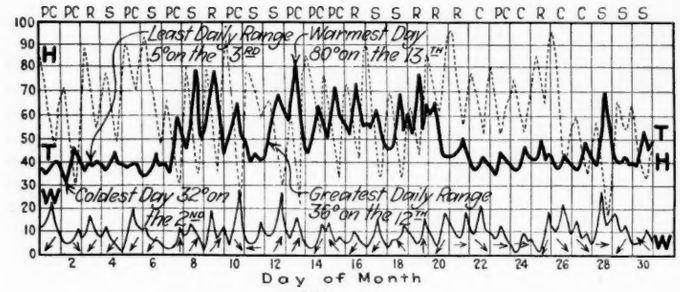

Least Daily Range 4° on the 1st
Greatest Daily Range 30° on the 13th
Warmest Day 78° on the 20th
Coldest Day 32° on the 12th
Day of Month

Boston

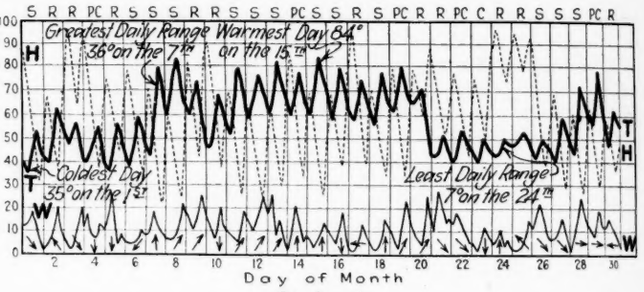

Least Daily Range 7° on the 7th
Greatest Daily Range 26° on the 13th
Warmest Day 69° on the 18th
Coldest Day 34° on the 12th
Day of Month

New York

(Hourly Observation of the Relative Humidity Plotted on this Chart.)


Least Daily Range 5° on the 3rd
Warmest Day 80° on the 13th
Coldest Day 32° on the 2nd
Greatest Daily Range 36° on the 12th
Day of Month

Chicago


Greatest Daily Range 36° on the 7th
Warmest Day 84° on the 15th
Coldest Day 35° on the 1st
Least Daily Range 7° on the 24th
Day of Month

St. Louis

	New York	Boston	Pittsburgh	Chicago	St. Louis
Highest temperature, deg. F.	69	78	80	80	84
Date of highest temperature	18	20	19	13	15
Lowest temperature, deg. F.	34	32	32	32	35
Date of lowest temperature	12	12	27	2	1
Greatest daily range, deg. F.	26	30	33	36	36
Date of greatest daily range	13	13	16	12	7
Least daily range, deg. F.	7	4	3	5	7
Date of least daily range	7	1	1	3	24
Mean temperature for month, deg. F.	50.4	50.2	50.6	49.2	57.3
Normal mean temperature for month, deg. F.	49.4	46.4	51.2	46.9	56.1
Total precipitation, this month, inches	3.30	3.12	3.61	1.75	3.23
Total snowfall, this month, inches	Trace	Trace	2.7	Trace	Trace
Normal precipitation, this month, inches	3.23	3.34	2.92	2.78	3.81
Total wind movement, this month, miles	11,600	6006	6867	6370	6889
Average hourly wind velocity, miles	16.1	8.3	9.5	8.8	9.6
Prevailing direction of wind	N.	N. W.	W.	N.E.	N.W.
Number of clear days	10	15	12	9	13
Number of partly cloudy days	8	5	5	12	11
Number of cloudy days	12	10	13	9	6
Number of days with precipitation	10	9	9	7	12
Number of days with snowfall	None	None	3	None	None
Snow on ground, at end of month	None	None	None	None	None

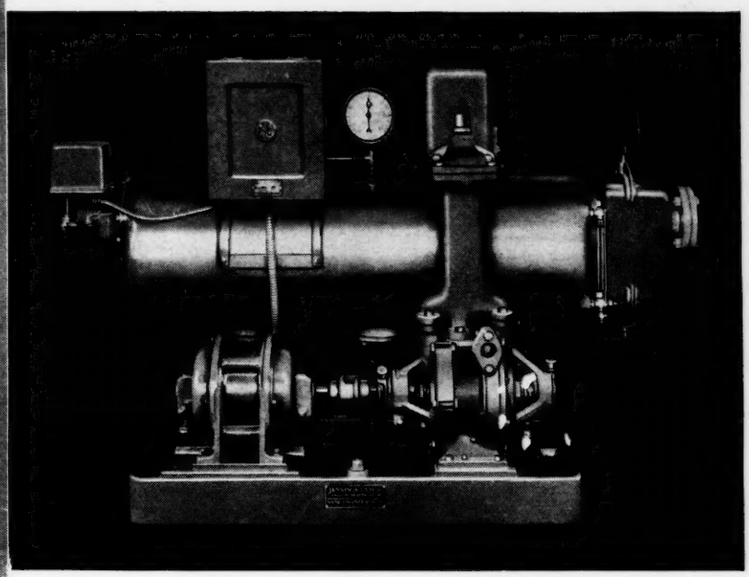
Plotted from records especially compiled for HEATING AND VENTILATING by the United States Weather Bureau.
Heavy lines indicate temperatures in degrees F. Light lines indicate wind in miles per hour.
Broken lines indicate humidity in percentage from readings at 8 a. m., 12 m., and 8 p. m. Arrows fly with prevailing directions of wind.
S—clear, PC—partly cloudy, C—cloudy, R—rain, Sn—snow.

AMPLE CAPACITY

to handle the extra loads

•

Jennings Vacuum Heating pumps are furnished in capacities of 4 to 400 g.p.m. of water and 3 to 171 cu. ft. per min. of air. For serving up to 300,000 sq. ft. equivalent direct radiation.



STARTING up a return line heating system in the morning throws a heavy load on the heating pump. Steam condenses rapidly in the cold radiators. Large quantities of water that have collected over night must be removed.

Ample capacity to handle these extra loads is built into the Jennings Vacuum Heating Pump. A Jennings consists of two independent units. One pumps only water, the other only air. Each unit is designed for maximum efficiency. Air capacity is not affected by the volume of water being pumped. Water capacity remains constant when air is being handled. This exclusive Jennings feature assures satisfactory heating pump performance.

For complete information, write for Bulletin 85.

NASH ENGINEERING COMPANY
81 Wilson Road So. Norwalk, Conn.

Jennings Pumps